

Meeting the 15-Percent Rate-of-Progress Requirement Under the Clean Air Act:

A Menu of Options

September 1993

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Acknowledgements

On behalf of the State and Territorial Air Pollution Program Administrators (STAPPA) and the Association of Local Air Pollution Control Officials, (ALAPCO), we are pleased to provide *Meeting the 15-Percent Rate-of-Progress Requirement Under the Clean Air Act: A Menu of Options*.

This document is intended to assist Moderate and above ozone nonattainment areas in identifying mobile, stationary and area source control measures to be considered for inclusion in an area's plan for achieving the reductions necessary to comply with the statutory mandate to reduce emissions of volatile organic compounds by 15 percent from 1990 levels by 1996.

As the November 15, 1993 deadline for submitting State Implementation Plans outlining 15-percent reduction strategies draws near, we are hopeful that this document will be a useful tool. In addition, we anticipate that the information provided will be helpful for future air quality control efforts as well. While we recognize that not all control options included in this document are appropriate for all areas, we encourage state and local air quality agencies to consider the options we have identified and, where appropriate, implement the recommendations offered by STAPPA and ALAPCO. Further, we stress the need for all

agencies to conduct their own thorough analyses of control options to ensure that the specific conditions of an area are adequately evaluated.

STAPPA and ALAPCO gratefully acknowledge the assistance of the U.S. Environmental Protection Agency's Office of Air Quality Planning and Standards (OAQPS) and Office of Mobile Sources (OMS) in the preparation of this document. In particular, we extend our appreciation to DAVID COLE and WILLIAM JOHNSON of OAQPS and JOHN CABANISS, GARY DOLCE and PHILIP LORANG of OMS, who were extremely helpful to our efforts. (We note that EPA's assistance in this STAPPA/ALAPCO project should not be construed as an endorsement of the analyses and recommendations included herein.)

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THOMAS M. ALLEN (New York)
STAPPA President

I. NEWTON VAUGHAN (Huntsville, Alabama)
ALAPCO President

Prepared by the

**State and Territorial Air Pollution Program Administrators
and the
Association of Local Air Pollution Control Officials**

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About STAPPA & ALAPCO

The State and Territorial Air Pollution Program Administrators (STAPPA) and the Association of Local Air Pollution Control Officials (ALAPCO) are the national associations of state and local air quality control officers in the states and territories and over 165 metropolitan areas across the country. The members of STAPPA and ALAPCO have primary responsibility for implementing our nation's air pollution control laws and regulations. Both associations serve to encourage the inter-

change of information and experience among air pollution control officials; enhance communication and cooperation among federal, state and local regulatory agencies; and promote air pollution control activities. STAPPA and ALAPCO have joint headquarters in Washington, DC.

For further information, contact STAPPA and ALAPCO at 444 North Capitol Street, NW, Suite 307, Washington, DC, 20001 (telephone: 202/624-7864).

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Introduction

BACKGROUND

The Clean Air Act Amendments of 1990 represent an unprecedented commitment to protecting public health and the environment. Title I of the Act classifies areas that exceed national health-based air quality standards based upon the severity of their pollution problem and, accordingly, prescribes increasingly stringent measures that must be implemented and sets new deadlines for achieving the standards. The Act also establishes specific interim emissions reduction requirements to ensure that continual progress toward attainment is made.

By November 15, 1993, all areas of the country classified as Moderate or above for ozone nonattainment must submit to the U.S. Environmental Protection Agency (EPA) a plan demonstrating how emissions of volatile organic compounds (VOCs) – which contribute to the formation of ozone – will be reduced by 15 percent from 1990 levels by 1996. Areas that fail to submit or implement an approvable plan within the applicable time frame will be subject to nondiscretionary economic sanctions in the form of withheld federal highway funds or requirements for new industrial sources to offset emissions.

Although the Act does, indeed, provide state and

local air quality agencies with an array of regulatory tools to reduce ozone – more commonly known as smog – in many of the 55 affected areas across the country, this reasonable further progress requirement will necessitate the implementation of additional control measures for mobile, stationary and area sources beyond those prescribed by the Act.

As the deadline for submitting 15-percent plans nears, state and local air regulators are finding compliance with this requirement to be increasingly challenging, particularly in light of the absence of anticipated federal measures, such as Control Techniques Guidelines, for many heretofore uncontrolled industrial sources of pollution.

STAPPA and ALAPCO have prepared this document to assist state and local air pollution control agencies with jurisdiction over a Moderate or above ozone nonattainment area in developing their 15-percent VOC reduction plans by November 15, 1993. This document includes a comprehensive listing of mobile, stationary and area source control options that should be considered for possible inclusion in a 15-percent reduction strategy.

For each mobile source control measure or stationary or area source category identified, we have provided background information, such as a source or measure

description, geographic distribution, a national emissions estimate and the potential for national reductions in emissions. In addition, we have included available control strategies or levels of control, as well as the reduction potential and cost effectiveness of each. A status report on the development of related federal regulations or guidance documents is also provided, as is a summary of state and local control efforts. Finally, STAPPA and ALAPCO's recommendation for a level of control is provided.

Not all of the control options identified in this document are suitable for all areas. However, we urge state and local air quality agencies to consider the options we have included and, where appropriate, implement the STAPPA/ALAPCO recommendation. A summary of STAPPA and ALAPCO's recommendations for each mobile, stationary and area source control option addressed in this document is included in Section I.

It should be noted that, although the primary focus of this document is on control options that will yield VOC emissions reductions by 1996, we have included several alternatives that offer minimal pre-1996 emissions benefits but substantial post-1996 reductions. Areas in need of post-1996 emissions reductions to meet continued reasonable further progress requirements or demonstrate maintenance of the standard should give consideration to implementing these long-term strategies expeditiously.

Finally, this document is intended to serve as a guide to assist state and local air quality agencies in determining which programs they should consider as they develop plans to meet the 15-percent reduction requirement of the Act. It is in no way intended to substitute for a thorough analysis by state and local agencies using appropriate EPA guidance and other available information.

SCOPE AND IMPLICATIONS OF THE OZONE NONATTAINMENT PROBLEM

Of the six criteria pollutants for which health-based National Ambient Air Quality Standards have been established – ozone, carbon monoxide, particulate matter, sulfur dioxide, nitrogen dioxide and lead – ozone poses the most pervasive problem.

Ozone is not emitted directly into the air in any significant quantity by any source, but, rather, results from chemical reactions that occur when precursor emissions of VOCs and nitrogen oxides (NO_x) are exposed to sunlight. Because of the role played by sunlight and high temperatures in the formation of ozone, peak ozone levels occur typically during the summertime.

Currently, 96 areas across the country are nonattainment for ambient ozone. The failure of these areas to meet the health-based ozone standard poses potential health

risks to the 140 million individuals who live and work in these areas. Although no one residing in an ozone nonattainment area appears to be totally immune to the adverse health effects related to excessive ozone concentrations, pre-adolescent children, adults over 65 years old and individuals who suffer from respiratory disease are most at risk.

EPA has concluded, however, that even healthy individuals who exercise during hours when ozone levels are at or slightly above the current 0.12-parts-per-million (ppm) standard can experience a decrease in lung function and may suffer from a variety of ailments, including chest pain, labored breathing, wheezing, coughing, sore throat, nausea, pulmonary and nasal congestion and increased respiratory rate, which do not always subside when the ozone episode passes. Moreover, studies have revealed not only that permanent lung damage may occur from repeated and prolonged exposure to ozone, but also that susceptibility to severe respiratory infection may result in normally healthy individuals even when levels of ozone are as much as one-third below the current health-based standard (i.e., 0.08 ppm).

In addition to health consequences, elevated ozone levels are also responsible for ecosystem and forest damage and for the loss of several billion dollars of agricultural crop yield each year, as well as noticeable foliar damage in many species of trees.

STATUTORY REQUIREMENT FOR REASONABLE FURTHER PROGRESS

To ensure that nonattainment areas make reasonable further progress toward achieving the ozone standard by the statutory deadlines, Section 182(b)(1)(A) of the Clean Air Act Amendments of 1990 mandates Moderate and above ozone nonattainment areas to achieve an actual 15-percent reduction in VOC emissions from 1990 levels by November 15, 1996; in achieving this reduction all growth in emissions that has occurred since 1990 must be offset. State Implementation Plans demonstrating a 15-percent reduction must be submitted to EPA by November 15, 1993.

Specifically, the Act requires that:

By no later than 3 years after the date of the enactment of the Clean Air Act Amendments of 1990, the State shall submit a revision to the applicable implementation plan to provide for volatile organic compound emission reductions, within 6 years after the date of enactment of the Clean Air Act Amendments of 1990, of at least 15 percent from baseline emissions, accounting for any growth in emissions after the year in which the Clean Air Act Amendments of 1990 are enact-

Calculating the Required Emissions Reduction

STEP 1:	Total 1990 Emissions	-	Biogenic Emissions	-	Emissions from Outside Nonattainment Area	-	Emissions Reductions from Pre-1990 FMVCP	-	Emissions Reductions from RVP Rules	=	1990 Adjusted Base Year Emissions
STEP 2:	1990 Adjusted Base Year Emissions	x	85%	-	Emissions Reductions from Corrections to RACT & I/M	=	1996 Target Emissions Inventory				
STEP 3:	Total 1990 Emissions	-	Biogenic Emissions	-	Emissions from Outside Nonattainment Area	+	Growth in Emissions Between 1990 & 1996	-	1996 Target Emissions Inventory	=	Total Required Emissions Reduction

ed. Such plan will provide for such specific annual reductions in emissions of volatile organic compounds and oxides of nitrogen as necessary to attain the national primary ambient air quality standard for ozone by the attainment date applicable under this Act. This subparagraph shall not apply in the case of oxides of nitrogen for those areas for which the Administrator determines (when the Administrator approves the plan or plan revision) that additional reductions in oxides of nitrogen would not contribute to attainment.

Under Section 182(c)(2)(B), Serious and above ozone nonattainment areas are also required to sustain progress toward achieving the standard by achieving reductions, on average, of three-percent per year until attainment, beginning in 1996. EPA guidance on reasonable further progress after 1996 is forthcoming.

CALCULATION OF 15-PERCENT VOC REDUCTION

As required by the Act, the 15-percent VOC reduction must be an actual reduction from the 1990 baseline. The Act defines baseline emissions for the purposes of this provision as "the total amount of actual VOC or NO_x emissions from all anthropogenic sources in the area during the calendar year of the enactment of the Clean Air Act

Amendments of 1990, excluding emissions that would be eliminated under the regulations described in clauses (i) [pre-1990 Federal Motor Vehicle Control Program (FMVCP) regulations] and (ii) [Reid Vapor Pressure (RVP) limits for nonattainment areas during peaks ozone seasons] under subparagraph (D)."

Accordingly, to calculate 1990 adjusted base year emissions, subtract emissions reductions from pre-1990 FMVCP measures and RVP rules, as well as emissions from outside the nonattainment boundary and from biogenic sources from total 1990 baseline emissions.

Next, calculate the projected 1996 target emissions inventory by multiplying the 1990 adjusted base year inventory by 0.85 (to determine the level of emissions that will remain after a 15-percent decrease) and subtract emissions reductions to be achieved from corrections to Reasonably Available Control Technology (RACT) rules and deficiencies in motor vehicle Inspection/Maintenance (I/M) programs, as required by the Act.

Finally, to determine the total required emissions reduction, subtract biogenic emissions, as well as emissions from outside the nonattainment area from total 1990 emissions. Then add in the full amount of projected growth in total emissions between 1990 and 1996 and subtract the 1996 target emissions inventory.

EPA GUIDANCE

EPA has published several technical guidance documents related to the development of 15-percent plans, including the following:

■ **Guidance on the Adjusted Base Year Emissions Inventory and the 1996 Target for the 15-Percent Rate-of-Progress Plans (October 1992)**

This document, which was prepared for the purposes of assisting in the development of November 1993 submittals, focuses on the calculation of the adjusted base year inventory and the 1996 target level of emissions and provides an example calculation; this document should be referred to for more detailed information on calculating required emissions reductions. The document also identifies special circumstances related to emissions inventories and emissions estimates that should be considered as 15-percent plans are developed and includes information on the format of submittals and on the level of credit that can be taken for various control programs.

■ **Guidelines for Estimating and Applying Rule Effectiveness for Ozone/CO State Implementation Plan Base Year Inventories (November 1992)**

This document describes EPA procedures for estimating the effectiveness of existing regulatory programs for controlling stationary source emissions. The three approaches addressed are 1) the detailed study protocol developed by the Stationary Source Compliance Division of the Office of Air Quality Planning and Standards (OAQPS), which involves on-site inspection and testing on a single source-category-by-source-category basis, 2) the generic questionnaire approach developed by the Air Quality Management Division of OAQPS, which solicits answers based upon available file information for specific sources and extrapolates the responses to other sources in the same category and 3) the use of the 80-percent default for estimating rule effectiveness. (A fourth method that can be used is a state-developed method, which must be approved in advance by EPA.)

Among the information included are definitions and discussion of various effectiveness measures, procedures for estimating category-specific rule-effectiveness values for areas that do not wish to apply the 80-percent default level, instructions on applying rule effectiveness to sources in the base year inventories and example calculations.

■ **Guidance for Growth Factors, Projections, and Control Strategies for the 15-Percent Rate-of-Progress Plans (March 1993)**

In addition to identifying references for detailed information related to a variety of different components of 15-percent plans, this document provides guidance on developing projected emissions inventories for 1996 and control measures to be included in 15-percent plans and includes methods for calculating VOC emissions reductions. The document addresses the statutory requirement that all growth between 1990 and 1996 be offset in the 15-percent plan by describing how growth factors, emissions reductions, rule effectiveness and rule penetration should be incorporated into calculations. Further, guidance on using actual versus allowable emissions when making projections is also included, as is a sample step-by-step checklist for use by state and local agencies as they develop their 15-percent plans. Other issues addressed in this document include contingency measures and the requirements for Marginal and Moderate area attainment demonstrations.

■ **Guidance on the Relationship Between the 15-Percent Rate-of-Progress Plans and Other Provisions of the Clean Air Act (May 1993)**

Information on the level of credit to be allowed for emissions reductions achieved from programs implemented both prior to enactment of and in compliance with the Clean Air Act Amendments of 1990 is included in this document. The document addresses New Source Review, hazardous air pollutant controls, New Source Performance Standards, required mobile source controls, emissions reduction requirements for stationary sources of NO_x, economic incentive programs and operating permit programs.

■ **Guidance on Preparing Enforceable Regulations and Compliance Programs for the 15-Percent Rate-of-Progress Plans (June 1993)**

The purpose of this document is to provide guidance on preparing enforceable regulations and compliance programs for 15-percent plans. Minimum criteria for developing enforceable control measures are included, as are citations for additional sources of information that can be referenced to determine how EPA will evaluate stationary and mobile source regulations included in a 15-percent plan. The document also provides guidance on EPA's forthcoming enhanced monitoring and compliance certification rules and discusses EPA criteria for measuring and determining source compliance.

■ **Guidance on Issues Related to 15-Percent Rate-of-Progress Plans (August 1993)**

This August 23, 1993 memorandum from Michael Shapiro, Acting Assistant Administrator of EPA's Office of Air and Radiation, addresses three important issues related

to the November 1993 SIP submittals.

Committal SIPs – EPA will not allow the submittal of commitments to adopt measures necessary for complying with the 15-percent reduction requirement; plans that include such commitments will not be considered approvable.

NO_x Substitutions for Contingency Measures – By November 15, 1993, all Moderate and above ozone nonattainment areas are required by the Act to adopt contingency measures to take effect in the event the area fails to achieve reasonable further progress or fails to attain the standard by the statutory deadline. Such contingency measures must provide for reductions in emissions of 3 percent of the adjusted base year inventory. Because the contingency measures must address both the failure to comply with reasonable further progress requirements and the failure to attain, the agency will allow measures for both VOCs and NO_x, provided VOC measures comprise at least one-tenth of the 3-percent reduction (i.e., 0.3 percent). In order to be deemed acceptable, all NO_x contingency measures must adhere to EPA's forthcoming NO_x substitution guidance; further, modeling evidence demonstrating the need for NO_x reductions must be provided. EPA will allow the submittal of committal SIPs for the contingency measures

due on November 15, 1993; such plans must include a commitment, accompanied by a schedule, for contingency measures to be adopted by November 15, 1994.

Waiver Provision – EPA has determined that, in areas that wish to exercise their option under Section 182(b)(1)(A)(ii) of the Act to submit a plan demonstrating a VOC reduction of less than 15 percent, operating permits are required for all VOC sources that emit or have the potential to emit 5 tons per year (tpy) or more. In order to qualify for this "waiver" of the 15-percent requirement, however, the Act requires that an area: 1) demonstrate that it has a New Source Review program that meets the requirements for Extreme ozone nonattainment areas, except that it must apply to all sources that emit or have the potential to emit 5 tpy or more of VOCs; 2) impose controls equivalent to Reasonably Available Control Technology on all 5-tpy or greater VOC sources; 3) demonstrate that its SIP includes all mobile and stationary source measures achieved in practice by sources in the same source category in nonattainment areas of the next higher classification; and 4) include in its plan all feasible measures, considering technological achievability and cost.

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SECTION I

Summary of STAPPA/ALAPCO Recommendations

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Summary of STAPPA/ALAPCO Recommendations

STAPPA/ALAPCO *Recommendations for Mobile Sources*

SOURCE CATEGORY	STAPPA/ALAPCO RECOMMENDATION
Motor Vehicle Inspection and Maintenance	Augment Inspection and Maintenance (I/M) programs – basic or enhanced – by increasing the model year coverage, increasing the vehicle class coverage, increasing the pre-1981 stringency rate and/or conducting inspections on an annual basis. Basic I/M areas may also add a pressure test or evaluate the benefits of adopting an enhanced I/M program.
Reformulated Gasoline	Opt into the federal reformulated gasoline program, provided the final regulations adopted by EPA are consistent with the terms of the agreement reached through the regulatory negotiation. Areas requiring significantly greater or lesser reductions than those that can be achieved through implementation of the federal reformulated gasoline program may consider adoption of an individual fuel reformulation under Section 211(c)(4), but should be aware that such individual reformulations will be much more difficult to enforce and will not offer the air toxics benefits of the federal reformulated gasoline program.
California Low-Emission Vehicles	Consider adoption of the California low-emission vehicle program, which has the potential to yield substantial benefits over time, particularly in the post-2000 timeframe, when additional mobile source emissions reductions will be difficult to obtain.
Clean-Fuel Fleets	Increase the reduction potential of a clean-fuel fleet vehicle (CFFV) program by requiring the purchase of more CFFVs than required in any year; the purchase of vehicles that meet stricter emissions standards; or the advance purchase of vehicles (before requirements take effect). Areas may also encourage non-covered fleets to participate. Areas not required to implement a CFFV program should consider adoption of such a program.
Non-Road Vehicles and Engines	Focus on achieving reductions from lawn and garden equipment and recreational vessels; consider the potential control strategies identified by STAPPA and ALAPCO.
Transportation Control Measures	Evaluate the potential effectiveness of transportation control measures based upon the particular needs and circumstances of a given area, with a special emphasis on pricing strategies, which offer the greatest potential for emissions reductions.
Employee Commute Options	Evaluate the additional emissions reductions that could be achieved by implementing an Employee Commute Options program.
Accelerated Vehicle Retirement	Consider implementation of an accelerated vehicle retirement, or "scrappage," program in conjunction with an I/M program.

STAPPA/ALAPCO***Recommendations for Stationary and Area Sources***

SOURCE CATEGORY	STAPPA/ALAPCO RECOMMENDATION
Adhesives	Adopt California's consumer product adhesive limits, supplemented by the industrial product adhesive limits of the South Coast Air Quality Management District (SCAQMD).
Aerosol Paints	Adopt the Bay Area Air Quality Management District's (BAAQMD's) rule. If additional reductions are needed, agencies may pursue a second set of standards similar to those of SCAQMD.
Aerospace Manufacturing and Rework	Set regulations no less stringent than the National Emission Standard for Hazardous Air Pollutants (NESHAP) EPA is currently developing. Agencies should note that EPA's recommendations for specialty coatings represent the status quo and are, in essence, exemptions from control. Areas should tailor their limits for specialty coatings to reflect local plant line-by-line operations.
Aluminum Rolling Mills	Require add-on controls achieving a 95-percent reduction in VOC emissions. Agencies may wish to exempt from control requirements those mills that use a lubricant having a VOC partial pressure of 20 mmHg or less at 20°C or containing 50 grams or less VOC per liter, less water and solvents.
Architectural and Industrial Maintenance Coatings	Adopt the rule resulting from the regulatory negotiation; in the interim, consider adopting California's Suggested Control Measure for Architectural Coatings.
Autobody Refinishing	Require high-volume, low pressure (HVLV) spray systems, gun-cleaning equipment and proper disposal for clean-up solvents; consider adopting California's Best Available Retrofit Control Technology limits.
Automobile Assembly	Require spray booth abatement at 5.8 lbs/gal, solids applied; without spray booth abatement, a 10-lbs/gal level is achievable.
Bakeries	Control ethanol emissions from baking ovens by at least 95 percent; consider exemptions based on lower emissions rates (e.g., 50-150 lbs of ethanol per day) or for smaller commercial bakeries (e.g., 50,000 lbs of baked goods per day, 2 MM Btu heat input).
Batch Processes	Set limits of 98-percent control efficiency, as achieved by current technologies (e.g., catalytic oxidizers); provide exemptions based on considerations of volatility, annual emissions and flow rate.
Coke By-product Recovery Plants	Implement the 1989 NESHAP for benzene emissions from coke by-product recovery plants.
Coke Oven Batteries	Implement the NESHAP proposed in December 1992 for coke oven batteries.
Commercial Ethylene Oxide Sterilization	Require 99-percent control from the main sterilizer vent and vacuum pump drains from ethylene oxide (EtO) sterilizers using greater than 600 pounds of EtO per year.
Consumer and Commercial Products	Adopt the California consumer products regulations.
Degreasing	Eliminate solvent degreasing on a case-by-case basis; consider alternative cleaners or cleaning processes.
Glass Forming	Prohibit petroleum-based lubricants (to be replaced with silicon-water emulsions) to eliminate glass-forming VOC emissions.
Graphic Arts - Rotogravure and Flexographic Printing	Require the installation of permanent total enclosures, where possible, and establish VOC limits for inks no less stringent than 300 grams per liter, less water and exempt solvents (2.5 lbs/gal). The use of low-solvent clean-up solutions (less than 30-percent solvent) or low-vapor-pressure clean-up solutions (less than 3 mmHg at 20°C) also represent reasonably available controls.
Highway Paints	Set VOC content limits no less stringent than 250 grams per liter; for areas seeking additional emission reductions, consider a limit of 150 grams per liter.
Industrial Wastewater Treatment	Enclose wastewater stream to point of treatment and require 95-percent control of volatiles or to 20 parts per million weight; consider applying regulations to wastewater streams with lower VOC concentration (e.g., 250 ppmw) than those identified in EPA's draft Control Techniques Guideline (CTG).
Iron and Steel Foundries	Adopt a rule similar to SCAQMD's, which requires combustion gas to be exhausted in a manner that limits the discharge of carbon monoxide to 2,000 parts per million volume or less.
Iron and Steel Industry/Sinter Plants	Require deoiling controls to levels no less stringent than 1 percent oil and grease for mill scale.

-continued

STAPPA/ALAPCO Recommendations for Stationary and Area Sources *—continued*

SOURCE CATEGORY	STAPPA/ALAPCO RECOMMENDATION
Landfill Gases	Implement the proposed New Source Performance Standard; lower the size cutoff to reflect the area's major source definition; consider regulating landfills with more than 500,000 tons in place.
Marina Gasoline Refueling	Require Stage I and II vapor recovery at marinas that dispense more than 10,000 gallons per month.
Marine Vessel Loading	Require at least 95-percent control efficiency from marine vessel loading operations.
Offset Lithographic Printing	Eliminate isopropyl alcohol; control emissions from ink dryers by 95 percent with additional controls; alternatively, require inks with a VOC content less than 300 grams per liter.
Pesticide Application	Limit pesticide applications during the ozone season; prohibit the use of solvent-containing fumigants during the ozone season or regulate emissions from fumigation chambers; and require the lowest VOC-emitting alternative.
Pharmaceuticals	Require the measures in the CTGs and draft CTGs that apply to pharmaceutical operations, including batch processes, industrial wastewater treatment, SOCM I reactor and distillation operations and air oxidation. Additionally, the proposed Hazardous Organic NESHAP (HON) addresses equipment leaks and could be used to regulate emissions from pharmaceutical plants.
Publicly Owned Treatment Works	Adopt source reduction approaches requiring industrial pretreatment, which can promote reduced VOC discharges to the wastewater stream and lower processing costs by controlling the VOCs where they are most concentrated.
Pulp and Paper	Implement the Maximum Achievable Control Technology standards for the integrated pulp and paper industry, expected to be published in late 1993.
Rule Effectiveness Improvement	Improve rule effectiveness beyond the presumptive 80-percent level set by EPA, which will provide additional VOC reduction credits.
Shipbuilding and Ship Repair	Require enhanced application techniques (e.g., HVLP spray), achieving a minimum 65-percent transfer efficiency; consider California's general limit of 340 grams per liter for marine coatings.
Stage II Vapor Recovery	Design rules to achieve a 95-percent level of control efficiency; require California certification of equipment; limit exemptions to facilities with a throughput of less than 10,000 gallons per month; and require semi-annual inspections. In addition, Moderate ozone nonattainment areas should seriously consider implementing a Stage II program.
Surface Coating of Plastic Parts	Require the following limits: 3.5 lbs/gal for air-dried or forced warm air-dried application, 3.5 lbs/gal for extreme performance application and 3.0 lbs/gal for all other applications; use HVLP spray or other techniques achieving a minimum transfer efficiency of 65 percent.
Synthetic Organic Chemical Manufacturing Industry (SOCMI) Reactor and Distillation Processes	Require a 98-percent reduction in emissions from SOCM I sources. Exemptions should be based on EPA's draft CTG, although agencies should use a total resource effectiveness (TRE) cutoff for exemptions that is higher (i.e., more stringent) than in the proposal to reflect costs being incurred by other sources in nonattainment areas.
Textile Finishing	Require add-on controls achieving a control efficiency of at least 95 percent; base capture efficiency on best engineering practices; and consider exempting low-solvent inks.
Treatment, Storage and Disposal Facilities	Coordinate with state hazardous waste officials to expedite the process of upgrading permits, once EPA publishes its hazardous waste rules (expected to be made final in the spring of 1994), and adopt separate air pollution control regulations for TSDFs, modeled after EPA's proposal.
Underground Storage Tank Vents	Require installation of pressure-vacuum valves on the open vent pipes of storage tanks equipped with Stage I vapor recovery. Set valves at 2.5 to 3 inches water column for pressure relief and 6 inches of water column for vacuum.
Volatile Organic Liquids Storage	Lower vapor pressure exemptions in current rules from 1.5 pounds per square inch actual (psia) to 0.5 psia and enhance test methods, monitoring specifications and equipment specifications based upon the draft HON rule and volatile organic liquid storage CTG.
Whiskey Distilleries	Require carbon adsorption at a capture and control level of no less than 85-percent.
Wood Furniture Coating	Adopt BAAQMD's Regulation 8, Rule 32 until the regulatory negotiation is completed.

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SECTION II

Mobile Source Control Strategies

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Mobile Source Control Strategies

INTRODUCTION

This portion of the document assesses the potential emissions reductions that could be achieved through the implementation of different variations of mobile source control strategies. In carrying out this analysis, a standard set of conditions was assumed for the vehicle fleet and its operations, including:

- the national vehicle mix;
- the national vehicle annual mileage distribution;
- the national vehicle age distribution;
- growth in vehicle miles traveled of 2.5 percent per year;
- Stage II vapor recovery in place by 1996 (77-percent effective for light-duty vehicles, 67-percent effective for heavy-duty vehicles);
- typical summer day conditions, with temperatures ranging from 68°F to 94°F;
- a good basic I/M program in effect by 1990 (assuming a program beginning in 1983, with annual testing of all 1968 and newer cars at test-only facilities, including an idle test at 20-percent

stringency, with no waivers, and cutpoints for 1981 and newer cars of 220 parts per million hydrocarbon and 1.2 percent carbon monoxide);

- American Society for Testing and Materials (ASTM) area Class C;
- average speed of 33 miles per hour; and
- total mileage of 1 million miles per day in 1990.

With respect to motor vehicle Inspection and Maintenance, reformulated gasoline and California low-emission vehicles, two overall scenarios were considered for each – one excluding non-road vehicles and engines and one including them. Both of these scenarios were considered because non-road vehicles and engines represent a very important source of volatile organic compound (VOC) and nitrogen oxide (NO_x) emissions in many areas. According to EPA, on a typical summer day, non-road vehicles and engines are responsible on a nationwide basis for 36 percent of the total motor vehicle and engine VOC emissions and 34 percent of the NO_x emissions.

Although there are substantial efforts currently underway both on the federal level and in California to regulate new non-road vehicles and engines, it is unlikely that

these efforts will result in any emissions impact prior to 1996, other than those associated with fuel reformulation. Therefore, for the scenarios including non-road vehicles, it was assumed that such sources would increase at a rate of 1 percent per year and that they would be uncontrolled, except where states take action.

Finally, it is important to note that the sequence with which strategies are introduced can have an important impact on the emissions reduction achieved. In addition, each individual element of the strategies may not be additive. For example, the benefits of reformulated gasoline in an area with an enhanced motor vehicle Inspection and Maintenance (I/M) program will not be the same as the benefits that will result in an area without an enhanced I/M program.

The information related to mobile source control strategies included in this section should be used by state and local air quality agencies to determine which programs they should consider in developing strategies to reduce motor vehicle emissions. However, it is not intended to be a substitute for a thorough state or local agency analysis using MOBILE5a, applicable EPA guidance documents and other available information, in that actual State Implementation Plan (SIP) credits will vary depending upon local conditions. For some programs, such as clean-fuel fleets and California reformulated gasoline, the U.S. Environmental Protection Agency (EPA) has not yet issued a final determination of benefits. Therefore, EPA cannot verify that the benefits identified for the programs addressed in this document reflect the actual SIP credits that will result.

Motor Vehicle Inspection and Maintenance

DESCRIPTION OF CONTROL MEASURE

Due to poor maintenance, deliberate tampering with or removal of pollution controls (particularly catalysts) and misfueling (i.e., using leaded fuel in vehicles that require unleaded fuel), motor vehicles in use have consistently been found to emit pollutants well in excess of the established standards. Motor vehicle Inspection and Maintenance (I/M) programs have been singled out as the primary means to rectify these problems by identifying vehicles in need of remedial maintenance or adjustment and, accordingly, requiring appropriate repairs. I/M programs are intended to encourage vehicle owners to keep their cars in a good state of repair, the service industry to conduct maintenance properly and manufacturers to make vehicles more durable and serviceable.

While I/M programs have been required by the federal Clean Air Act since 1977, details of program implementation have generally been left to the discretion of state or local officials, with broad policy guidelines from EPA. With adoption of the Clean Air Act Amendments of 1990 (CAAA), this approach changed. Both the House and Senate made "enhanced" I/M a cornerstone of their clean air bills. The I/M provisions of the House bill, which were

ultimately adopted in Conference, were especially strong—requiring annual, test-only programs or programs that achieve equivalent reductions in more seriously polluted areas. In addition, a minimum repair cost waiver of \$450 was established and, for the first time, nitrogen oxides (NO_x) testing was required in ozone nonattainment areas.

Pursuant to the CAAA, Moderate ozone nonattainment areas, as well as Marginal ozone nonattainment areas previously required to have an I/M program, must implement "basic" I/M requirements. "Enhanced" I/M programs are required in Serious, Severe and Extreme ozone nonattainment areas with urbanized populations of 200,000 or more. In addition, carbon monoxide (CO) nonattainment areas with a design value exceeding 12.7 parts per million (ppm) and with an urbanized population of 200,000 or more, as well as all Metropolitan Statistical Areas with a population of 100,000 or more in the Northeast Ozone Transport Region must also implement enhanced I/M.

For the purposes of implementing the I/M provisions of the CAAA, EPA has adopted the concept of a model program, based upon a performance standard with which areas have flexibility to design their own particular I/M programs. An area is essentially required to

determine the emissions reductions that would be achieved by the model program when applied to the affected vehicle fleet using the most current version of the mobile source emissions model. The area must demonstrate, using the same model, that its program will achieve the same or greater emissions reductions. An area's air quality status will determine which performance standard(s) (ozone, CO or both) apply.

Basic I/M Performance Standard: Areas required to implement a basic I/M program must achieve at least as great a reduction in emissions as a model program that includes the following elements:

- test only;
- a start date of 1983;
- annual testing;
- applicability to all 1968 and later model year light-duty vehicles;
- an idle test;
- no emissions control device inspections;
- a 20-percent emissions test failure rate among pre-1981 model year vehicles;
- a 0-percent waiver rate;
- a 100-percent compliance rate;
- testing of the vehicle's onboard diagnostic (OBD) system (applicable to vehicles certified to comply with OBD regulations; EPA will be establishing specific requirements, now that a final OBD regulation has been promulgated); and
- emissions standards no weaker than specified in 40 CFR, part 85, subpart W.

Basic I/M programs must be shown to achieve the same or lower emissions levels as the model inputs by 1997 for ozone nonattainment areas and by 1996 for CO nonattainment areas. As noted earlier, this basic I/M program was assumed to apply in the 1990 base case.

Enhanced I/M Performance Standard: To comply with the enhanced I/M requirements of the CAAA, EPA has defined a model program that includes the following elements:

- test only;
- a start date of in 1983 for existing areas or 1994 for newly subject areas;
- annual testing;
- applicability to all 1968 and later model year light-duty vehicles and light-duty trucks rated up to

8,500 pounds Gross Vehicle Weight Rating (GVWR);

- transient mass emission testing on 1986 and later model year vehicles using the IM240 driving cycle, two-speed testing of 1981-1985 vehicles and idle testing of pre-1981 vehicles;
- maximum exhaust dilution measured as no less than 6 percent CO plus carbon dioxide (CO₂) on vehicles subject to a steady-state test;
- visual inspection of the catalyst and fuel inlet restrictor on all 1984 and later model year vehicles;
- an evaporative system integrity (pressure) test on 1983 and later model year vehicles and an evaporative system transient purge test on 1986 and later model year vehicles;
- a 20-percent emission test failure rate among pre-1981 model year vehicles;
- a 3-percent waiver rate as a percentage of failed vehicles;
- a 96-percent compliance rate;
- on-road testing of 0.5 percent of the subject vehicle population (as a supplement to the periodic inspection), to measure annually hydrocarbons (HC), CO, NO_x and/or CO₂ emissions on any road or roadside in the nonattainment area or the I/M program area;
- testing of the vehicle's OBD system (applicable to vehicles certified to comply with OBD regulations; EPA will be establishing specific requirements, now that a final OBD regulation has been promulgated); and
- emissions standards as follow:
 - for 1986 through 1993 model year light-duty vehicles and 1994 and 1995 light-duty vehicles not meeting Tier 1 standards, emissions standards of 0.80 grams per mile (gpm) HC, 20 gpm CO and 2.0 gpm NO_x apply;
 - for 1986 through 1993 model year light-duty trucks less than 6,000 pounds GVWR and 1994 and 1995 light-duty trucks not meeting Tier 1 standards, emissions standards of 0.80 gpm HC, 15 gpm CO and 2.5 gpm NO_x apply;
 - for 1986 through 1993 model year light-duty trucks greater than 6,000 pounds GVWR and 1994 and 1995 light-duty trucks not meeting Tier 1 standards, emissions standards of 0.80 gpm HC, 15 gpm CO and 3.0 gpm NO_x apply;

- for 1994 and later light-duty vehicles meeting Tier 1 standards, emissions standards of 0.70 gpm non-methane hydrocarbons (NMHC), 15 gpm CO and 1.4 gpm NO_x apply;
- for 1994 and later light-duty trucks under 6,000 pounds GVWR and meeting Tier 1 standards, emissions standards of 0.70 gpm NMHC, 15 gpm CO and 2.0 gpm NO_x apply;
- for 1994 and later light-duty trucks greater than 6,000 pounds GVWR and meeting Tier 1 standards, emissions standards of 0.80 gpm NMHC, 15 gpm CO and 2.5 gpm NO_x apply; and
- for 1981 through 1985 model year vehicles, standards of 1.2 percent CO and 220 ppm HC for the idle, two-speed tests and loaded steady-state tests apply.

Enhanced I/M programs must be shown to obtain the same or lower emissions levels as the model inputs by 2000 for ozone nonattainment areas and 2001 for CO nonattainment areas. In Severe and Extreme ozone nonattainment areas, such a demonstration must also be made on each applicable milestone and attainment deadline thereafter; milestones for NO_x must be the same as those for ozone.

AVAILABLE CONTROL STRATEGIES

Reductions achieved by an enhanced I/M program, over and above those that would be achieved by a basic I/M program, are creditable toward the 15-percent VOC reduction requirement and, where necessary, to the 3-percent additional reduction thereafter.

EPA has developed a model program to define the enhanced I/M performance standard. Although this performance standard is based upon an annual program, areas have the option of adopting a biennial program that achieves equivalent emissions benefits by 1999. Since the emissions benefits of such a biennial program in 1996 would not be significantly different from an annual program performance standard in 1996, such a case has not been addressed here.

Areas that wish to achieve higher levels of emissions reductions from their enhanced I/M programs in order to meet their 1996 and subsequent-year reasonable further progress targets can do so by, among other things, increasing the model year coverage, increasing the vehicle class coverage, increasing the pre-1981 stringency rate or adopting an annual program.

To illustrate the potential benefits of programs that

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► Areas required to implement a basic I/M program may consider augmenting their program by increasing the model year coverage, increasing the vehicle class coverage, increasing the pre-1981 stringency rate and/or conducting inspections on an annual basis. Further, fairly substantial benefits can be achieved from a basic I/M program by adding a pressure test; such an addition can be accomplished without the incorporation of IM240. Basic areas may also wish to evaluate the benefits of adopting an enhanced I/M program.

Areas required to implement an enhanced I/M program may wish to expand this program by increasing the model year coverage, increasing the vehicle class coverage, increasing the pre-1981 stringency rate and/or conducting inspections on an annual basis.

go beyond the minimum requirements, two alternative programs were modeled. In the first scenario – called “maximum coverage” I/M – the vehicle population subject to I/M is expanded to include all categories of gasoline-fueled vehicles. In addition, IM240 and purge and pressure tests are used for all 1975 and newer vehicles.

In the second scenario – called “maximum overall” I/M – in addition to broader vehicle coverage, all inspected vehicles are subject to anti-tampering inspection of all components.

Other variations are, of course, possible, but the options addressed here provide an indication of the additional emissions reduction potential of adopting a more aggressive I/M program than required by EPA.

POTENTIAL NATIONAL EMISSIONS REDUCTION

Figures 1 through 4 summarize the emissions reduction potential of enhanced I/M, “maximum coverage I/M” and “maximum overall” I/M. As depicted, by 1996, enhanced

I/M can reduce VOC emissions from highway vehicles by 11 percent from an adjusted 1990 baseline. "Maximum coverage" I/M can increase reductions to 20 percent, while with a "maximum overall" I/M program, reductions can increase to 23 percent. By 1999, these reductions would grow to approximately 24 percent, 32 percent and 33 percent, respectively; by 2002, to 32 percent, 40 and 40 percent, respectively; and by 2005, to 37 percent, 43 and 43 percent, respectively.

I/M programs can also result in significant NO_x reductions from the adjusted 1990 baseline. It is important to note that, although overall NO_x emissions will decrease from actual 1990 levels by 1996, when compared to the adjusted 1990 baseline, NO_x emissions from mobile sources in 1996 will, in fact, increase as a result of the assumed 2.5 percent annual growth in vehicle miles traveled. Therefore, with an I/M program in place, the net increase in NO_x emissions for model year 1996 will be lower than if there were no I/M program in place.

Figures 3 and 4 illustrate the impact of I/M on overall motor vehicle emissions, including uncontrolled and growing non-road emissions. Not surprisingly, the overall percentage benefits decline. (Please note, however, that these two estimates do not apply I/M to non-road vehicles and engines but, rather, show the relative impact of I/M programs for highway vehicles on overall motor vehicle emissions, including those from non-road sources. The chapter on non-road vehicles and engines provides information on the control of this source category.)

COST EFFECTIVENESS

EPA has estimated the inspection cost of the model enhanced I/M program to be \$17 per vehicle in an effectively run, high-volume program. If the inspection were performed biennially, and extended to 1984 and 1985 model year vehicles, the estimated annual per vehicle cost would be approximately \$9. A biennial version of enhanced I/M that expands transient and purge testing back to the 1984 model year and pressure testing back to the 1971 model year, should achieve equivalent emissions, while substantially improving cost effectiveness.

EPA estimates the cost effectiveness of a biennial I/M program to be approximately \$500 per ton of VOCs.

FEDERAL RULEMAKING AND/OR GUIDANCE DOCUMENTS

On November 5, 1992, EPA published a final I/M rule (57 FR 52950). In addition, the agency has issued a number of guidance documents related to I/M (see References section).

Most areas required to implement enhanced I/M programs are proceeding to fulfill their commitments. With only a few exceptions, areas have obtained appropriate legal authority and plan to submit adequate I/M State Implementation Plans (SIPs) this November.

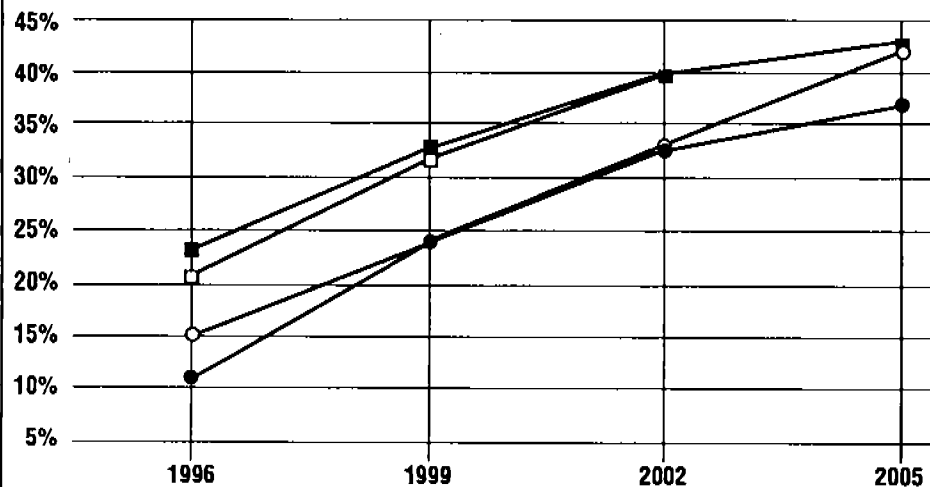
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Figure 1

Impact of I/M Options on VOC Emissions

Percent Reduction From Adjusted 1990 Baseline — Highway Vehicles Only



- Enhanced
- Maximum Coverage
- Requirement*
- Maximum Overall

*Assumes proportional reduction from mobile and all other sources

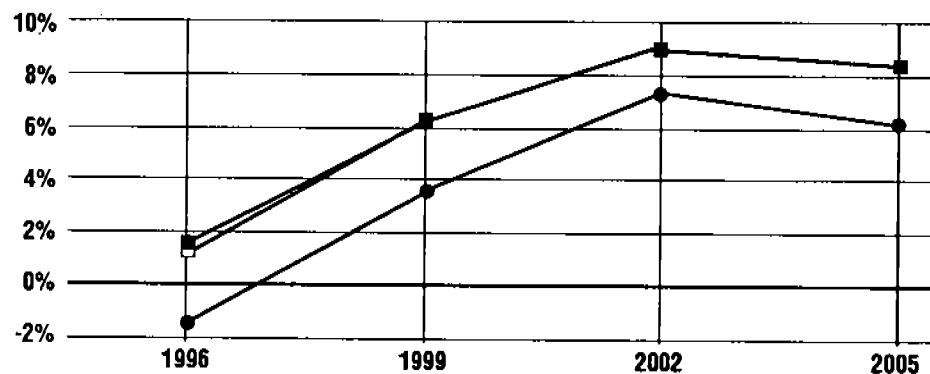
11.07%	23.84%	32.45%	37.00%
20.43%	31.68%	39.69%	42.85%
15.00%	24.00%	33.00%	42.00%
23.03%	32.80%	39.69%	42.85%

Enhanced
Maximum Coverage
Requirement*
Maximum Overall

Figure 2

Impact of I/M Options on NO_x Emissions

Percent Reduction From Adjusted 1990 Baseline — Highway Vehicles Only



- Enhanced
- Maximum Coverage
- Requirement*
- Maximum Overall

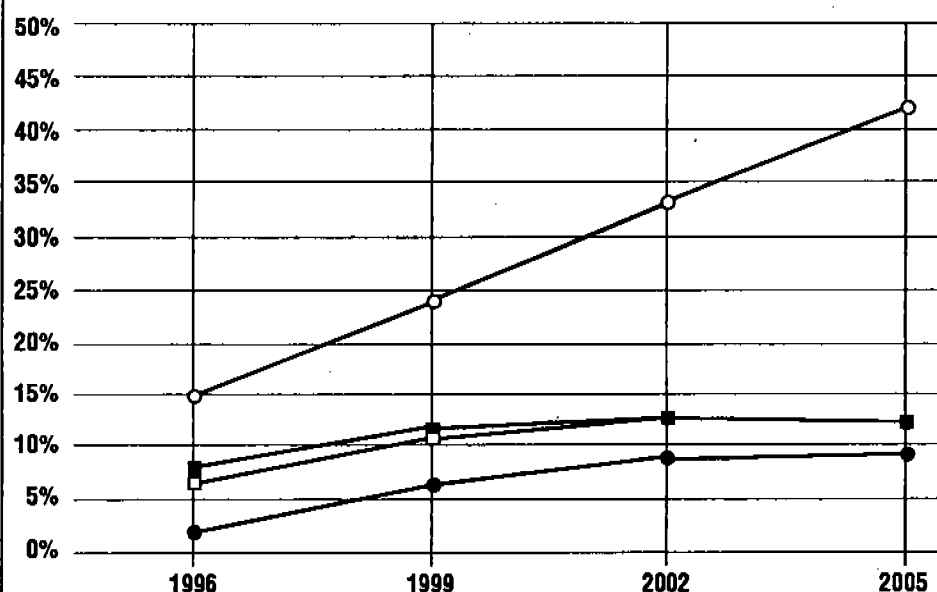
-1.47%	3.90%	7.54%	6.09%
1.24%	6.34%	9.11%	8.35%
1.70%	6.34%	9.11%	8.35%

Enhanced
Maximum Coverage
Maximum Overall

Figure 3

Impact of I/M Options on VOC Emissions

Percent Reduction From Adjusted 1990 Baseline — Highway and Non-Road Vehicles



- Enhanced
- Maximum Coverage
- Requirement*
- Maximum Overall

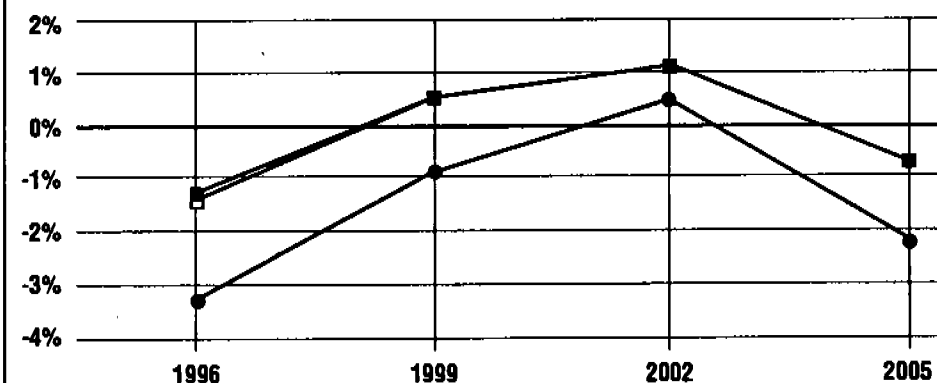
*Assumes proportional reduction from mobile and all other sources

Enhanced
Maximum Coverage
Requirement*
Maximum Overall

Figure 4

Impact of I/M Options on NO_x Emissions

Percent Reduction From Adjusted 1990 Baseline — Highway and Non-Road Vehicles



- Enhanced
- Maximum Coverage
- Requirement*
- Maximum Overall

Enhanced
Maximum Coverage
Requirement*
Maximum Overall

Reformulated Gasoline

DESCRIPTION OF CONTROL MEASURE

Federal Reformulated Gasoline: The Clean Air Act Amendments of 1990 (CAAA) require significant changes to conventional fuels. For areas that exceed the health-based ozone standard, the CAAA require the U.S. Environmental Protection Agency (EPA) to establish specifications for reformulated gasoline that would achieve the "greatest reduction" of ozone-forming volatile organic compounds (VOCs) and toxic air pollutants achievable, considering costs and technological feasibility.

Beginning January 1, 1995, this cleaner, "reformulated" gasoline must be sold in areas of the country with the worst nonattainment problems and populations over 250,000. Accordingly, use of reformulated gasoline is mandated, beginning in 1995, in nine areas – Baltimore, Chicago, Hartford, Houston, Los Angeles, Milwaukee, New York, Philadelphia and San Diego. Other ozone nonattainment areas are permitted to "opt-in" to the federal reformulated gasoline program, provided sufficient quantities of fuel can be made available.

At a minimum, reformulated gasoline must 1) not cause an increase in nitrogen oxides (NO_x) emissions (if necessary, EPA may modify other requirements discussed

below to prevent such an increase), 2) have an oxygen content of at least 2.0 percent by weight (EPA may waive this requirement if it would interfere with attaining an air quality standard), 3) have a benzene content no greater than 1.0 percent by volume and 4) contain no heavy metals, including lead or manganese (EPA may waive the prohibition against heavy metals other than lead if it is determined that the metal will not increase, on an aggregate mass or cancer-risk basis, toxic air emissions from motor vehicles).

Most importantly, the CAAA require that, beginning in 1995, reformulated gasoline result in summertime emissions of VOCs and year-round emissions of air toxics that are 15 percent lower than those that would occur from the use of normal "baseline" gasoline; by the year 2000, these emissions must be 25 percent lower. EPA may adjust the 25-percent requirement up or down based upon technological feasibility and cost considerations, but in no event may the percent reduction beginning in the year 2000 be less than 20 percent. Toxic air pollutants are defined by the CAAA in terms of the aggregate emissions of benzene, 1,3 butadiene, polycyclic organic matter, acetaldehyde and formaldehyde.

One concern raised during the Congressional debate was that toxic or other harmful compounds removed from

gasoline in polluted areas would be "dumped" into gasoline in other parts of the country. To prevent this, EPA was required to establish regulations prohibiting the introduction into commerce of gasoline that, on average, results in emissions of VOC, NO_x or toxics greater than gasoline sold by that refiner, blender or importer in 1990. These regulations must take effect by January 1, 1995.

Shortly after passage of the CAAA, EPA entered into a regulatory negotiation with interested parties to develop specific proposals for implementing both the reformulated gasoline and related anti-dumping programs. These parties included representatives of state and local air pollution control agencies, the oil and automobile industries, oxygenate suppliers, gasoline retailers, environmental organizations, citizens' groups and the Administration. One of the most difficult issues addressed in these negotiations was the determination of acceptable levels of oxygenates to achieve low VOC levels while constraining the growth of NO_x or other emissions. The issue was complicated by several factors, including the variety of oxygenates that could be added to gasoline and the differing impacts each can have on NO_x, the potential impact of other fuel characteristics and the impact of oxygenates on direct particulate emissions.

On Friday, August 16, 1991, following very intense negotiations, a unanimous agreement was signed by all negotiators. Accordingly, EPA agreed to propose a two-step approach to reformulated gasoline. The first step would take effect in 1995 and utilize a "simple model" to certify that a gasoline meets applicable emissions reduction standards. Under the second step, EPA would propose a "complex model" to supplant the simple model for certifying compliance with these standards, which would take effect on March 1, 1997 or four years after it is promulgated, whichever is later. EPA also agreed to propose the more stringent emissions performance standards provided for in the CAAA, to take effect in the year 2000.

It was agreed that the complex model would be developed by November 1992 and finalized by May 1993 and would address emissions reductions goals for the year 2000 – the so-called phase II of the reformulated gasoline program. Refiners would be required to submit their reformulated gasoline that had been approved under the simple model for recertification under the complex model by 1997.

To provide assurance that NO_x emissions would not rise under the simple model, a variety of options was agreed to by participants to the negotiation. The use of any oxygenate was allowed at levels up to and equal to 2.1 percent. Above that level, only methyl tertiary butyl ether (MTBE) was presumptively permitted to be blended up to 2.7 percent. Alternatively, a refiner could opt to use the

complex model to certify the fuel. For the simple model, a 2-percent oxygen standard and 7.2 Reid Vapor Pressure (RVP) for Class B areas and 8.1 RVP for Class C areas were assumed. Caps on certain fuel parameters, such as sulfur, would be based on the refiner's 1990 average fuel.

California Reformulated Gasoline: On September 18, 1992, the California Air Resources Board (CARB) adopted regulations for its Phase 2 reformulated gasoline program. These regulations establish a comprehensive set of gasoline specifications designed to achieve maximum reductions in emissions of VOCs, NO_x, carbon monoxide (CO), sulfur dioxide and toxic air pollutants from gasoline-fueled vehicles. CARB has stated that the primary purpose of its Phase 2 gasoline reformulation is to reduce pollutant emissions from the existing fleet of pre-low-emission vehicles.

The California Phase 2 reformulated gasoline regulations establish standards for eight gasoline characteristics – sulfur, benzene, olefin, aromatic hydrocarbons, oxygen, RVP, T-90 and T-50 – applicable starting March 1, 1996. The regulations also provide for the certification of alternative gasoline formulations based on vehicle emissions testing.

The standards for the six properties other than RVP and oxygen content are set in two tiers; each property has an absolute limit, or "cap," that will apply to all gasoline (including alternative formulations) throughout the distribution system, and a more stringent standard that will apply to gasoline as it is supplied by the refiner or importer. A refiner or importer will have two options for each of the more stringent standards. It may meet a "flat" limit, not to be exceeded by any batch of gasoline, or it can meet a lower limit on average for many batches, as long as no batch exceeds the cap.

Through testing or (as it is planned) modeling, a refiner may establish an alternative set of flat or averaging standards (but not caps) under which to produce gasoline. Such alternative standards must be demonstrated to not cause emissions greater than those attributable to the basic standards.

The RVP standard of 7.0 pounds per square inch (psi) applies during summertime control periods to all gasoline throughout the distribution system, including gasoline certified as an alternative formulation. The oxygen content standards consist of a cap applicable to all gasoline (1.8 percent minimum and 2.7 percent maximum) and a flat limit for producers and importers (1.8 percent minimum and 2.2 percent maximum). The designated alternative limit option does not apply to the oxygen or RVP standards. All the standards will apply year-round, beginning in 1996. Table 1 identifies these standards.

EPA has compared the properties of California

reformulated gasoline to the properties of federal reformulated gasoline, and the VOC, toxic and NO_x emissions that result from each, and has concluded that while the costs are higher, compared to Clean Air Act baseline gasoline, California reformulated gasoline has a greater emissions performance reduction than phase I federal reformulated gasoline.

AVAILABLE CONTROL STRATEGIES

States and localities have several options with respect to conventional fuels. First, as noted above, they can opt into the federal reformulated gasoline program. Alternatively, they can exercise the provisions of Section 211(c)(4) of the CAAA and adopt their own reformulated program. In addition, short of adopting the entire federal reformulated gasoline package, areas could choose to focus solely on fuel volatility, as eight northeastern states did prior to the 1990 enactment of the CAAA. Two alternatives are investigated here; in the first, an RVP of 8.1 – the same as in the federal reformulated gasoline program – is applied; in the second, an RVP of 7.0 – similar to that in California's reformulated gasoline program – is assumed to take effect.

POTENTIAL NATIONAL EMISSIONS REDUCTION

In its February 26, 1993 *Federal Register* proposal on federal reformulated gasoline (58 FR 11722), EPA estimated the impacts of reformulated gasoline on emissions. Tables 2 through 10, excerpted from the *Federal Register*, reflect these estimates. All VOC emissions estimates are expressed in terms of non-methane, non-ethane hydrocarbon emissions.

Table 2 illustrates EPA's estimates of VOC and NO_x emissions from in-use, 1990 technology vehicles when fueled with Clean Air Act baseline gasoline.

The summer performance of the fuels described in Table 3 is summarized in Tables 4 and 5, relative to the CAAA baseline fuel according to both the simple and complex emissions models. Table 6 summarizes EPA's estimate of the emissions performance of Fuels 3 and 4 relative to the Class B baseline fuel using both models. Tables 4, 5 and 6 use baseline emissions derived using the July 11, 1991 pre-release version of MOBILE4.1 with essentially a basic I/M program.

It should be noted that the above fuels show slight NO_x emissions increases when using the complex model. EPA believes that this occurs because Fuels 1 through 4 assume the oxygenate will have no effect on fuel sulfur, T50 and T90, and a minimal effect on fuel aromatics. When the typical effects of an oxygenate on these fuel parameters are taken into account, as EPA anticipates will occur on aver-

age under the simple model, EPA expects NO_x emissions increases not only to disappear, but to actually decrease slightly at both 2.1 and 2.7 percent oxygen by weight, regardless of the oxygenate used. The same holds true for the results shown in Tables 7 through 10 below.

For the purposes of comparison, Tables 7 through 10 summarize the summer performance of the fuels described in Table 3 relative to the CAAA baseline fuel according to two alternative phase I complex models. The complex model used to derive the results in Tables 7 and 8 utilized baseline emissions from MOBILE5.0, while the complex model used to derive the results in Tables 9 and 10 utilized baseline emissions from the official version of MOBILE4.1. Both alternative phase I complex models assumed basic I/M.

For this analysis, the emissions reductions from federal reformulated gasoline, California reformulated gasoline and two low-RVP scenarios were studied; the results are depicted in Figures 1 through 8. The benefits of federal reformulated gasoline and lower RVP limits were calculated using MOBILE5a. For California reformulated gasoline, the exhaust emissions reduction factor was applied to the gasoline exhaust emissions from MOBILE5a with baseline fuel. This factor was developed by EPA during the early stages of development of the complex model and does not represent EPA's final assessment of the exhaust benefits of California reformulated gasoline. In all cases it was assumed that EPA's model enhanced I/M program was in effect.

Figure 1 illustrates that the combination of federal reformulated gasoline and enhanced I/M significantly reduced on-road vehicle emissions; by 1996, VOC emissions would be reduced by approximately 22 percent compared to 11 percent with enhanced I/M alone. Adopting only the low volatility – 8.1 psi – associated with the federal reformulated gasoline program would reduce emissions by almost 17 percent. If very low volatility fuel, such as the 7.0 psi associated with California reformulated gasoline, were adopted, the overall reductions would increase to over 26 percent in 1996. Finally, introduction of California Phase 2 reformulated gasoline could increase the benefit to over 36 percent.

Figure 2 illustrates the VOC impacts of these fuels when unregulated non-road engines are included in the baseline.

For NO_x , as illustrated in Figure 3, the benefits, if any, of fuel modifications are minimal, except for the adoption of California reformulated gasoline. With this fuel there would be a benefit of approximately 2 percent beyond that which would be achieved with enhanced I/M alone. (Please note that in its February 26, 1993 reformulated gasoline proposal, EPA solicited comments on sever-

al scenarios, with NO_x benefits ranging from zero to 8 percent.)

Figure 4 depicts NO_x benefits when unregulated non-road engines are included in the baseline.

Figures 5 through 8 illustrate the incremental benefits of the fuels options investigated over and above the benefits of enhanced I/M.

As illustrated in the chapter on I/M, when the unregulated non-road vehicles and engines are added to the overall baseline, the percentage gains from fuel modifications are less. It is important to note that while the use of reformulated gasoline will result in reduced emissions from non-road vehicles and engines, this chapter addresses only the benefits for highway vehicle emissions. Please refer to the chapter on non-road vehicles and engines for discussion on the impact of reformulated gasoline on non-road sources.

COST EFFECTIVENESS

It is difficult to estimate the costs and the cost effectiveness of federal fuel modifications because the requirements are usually written in terms of a performance outcome that can be achieved in many different ways. In addition, refiners differ widely in terms of the characteristics of the fuels they produce. The methodology used by EPA for determining the cost effectiveness of fuel component changes is described in its Draft Regulatory Impact Analysis. Individual fuel component control costs and the effects of changes in one fuel component on the other fuel components are integral factors in the determination of the cost effectiveness. In EPA's analysis, these two integral factors were estimated from the results of refinery modeling performed by Turner, Mason and Company (for the Auto-Oil Economics group) and Bonner and Moore Management Science (for EPA) and on survey results presented by CARB.

Individual fuel component control costs include operating costs and annualized capital costs. All emissions reductions for Class C areas are calculated relative to the statutory baseline per the requirements of the CAAA and all emissions reductions for Class B areas are calculated relative to a fuel with an RVP of 7.8 psi and statutory baseline levels for all other parameters. As with phase I reformulated gasoline, all phase II reformulated gasoline must have at least 2.0 percent oxygen by weight and a maximum 1.0 percent benzene by volume. The cost of these requirements is not accounted for in the determination of the incremental cost effectiveness of the phase II standards. The cost effectiveness of incremental changes in fuel components is, therefore, determined relative to the statutory baseline and the mandated reformulated gasoline requirements.

The total cost (or manufacturing cost) of producing a reformulated gasoline is the sum of the capital recovery cost and the operating cost. Examples of the individual fuel component costs and the associated incremental percent reduction in VOC emissions for Class C areas are shown in Table 11.

In EPA's analysis, the incremental cost effectiveness of an emissions control obtained through fuel modifications is the ratio of the cost of a fuel component change to the additional reduction in emissions that occurs because of that fuel change. In determining the emissions reductions and the associated cost effectiveness of VOC and NO_x standards, EPA employed a convention typically used in estimating the benefit of both mobile and stationary source VOC controls. This convention requires the determination of cost effectiveness on the basis of annual tons of VOC reduced. Therefore, even though decreases in VOC emissions reduce ozone formation only during the high ozone season, the convention is to calculate the cost of the fuel component control per ton of VOC removed as if the high ozone season emissions reductions were obtained over the whole year.

EPA proposed a range of VOC standards and NO_x standards based upon particular combinations of fuel component controls that reduce VOC and VOC-plus- NO_x emissions at a cost of less than \$5,000 and less than \$10,000 per ton, respectively. EPA believes that these ranges represent the upper limit of costs that will be incurred by many ozone nonattainment areas in achieving attainment.

Based upon the complex model and the refinery modeling studies described above, EPA has concluded that the VOC performance standards listed in Row A of Table 12 could be met under the various RVP and cost-per-ton limits.

EPA also proposed a range of NO_x standards for comment. The benefits of the proposed standards under consideration range from zero to those shown in Row B of Table 12. With respect to VOCs, the NO_x emissions controls would apply only during the high ozone season.

The costs of these NO_x reductions range from less than \$1,000 per ton of NO_x to as high as \$5,500 per ton of VOC plus NO_x . EPA has found that the costs of other NO_x control programs range from \$300 to \$6,000 per ton of NO_x .

The additional fuel component changes that yielded the proposed NO_x standards also further decreased VOC emissions. While these fuel component changes were not cost-effective when based solely upon VOC control, they are cost-effective using the \$5,000 and \$10,000 per ton of VOC-plus- NO_x targets. The VOC standards achievable within these cost effectiveness limits when both VOC and

NO_x control are considered are shown in Row C of Table 12.

EPA has evaluated both driveability and safety concerns associated with the use of low-RVP fuels and found no significant negative impacts.

Estimates of the costs and cost effectiveness of California reformulated gasoline continue to decline. At the time it developed its regulations, CARB estimated the costs to be \$0.12 to \$0.17 per gallon. A recent analysis by Dr. R. Dwight Atkinson of EPA's Office of Policy, Planning and Evaluation (*The Case for California Reformulated Gasoline – Adoption by the Northeast*, May 1993) placed the costs at \$0.08 to \$0.11 per gallon. This analysis estimated the cost effectiveness of California reformulated gasoline to be \$4,100 to \$5,100 per ton of VOC and NO_x control; federal phase I reformulated gasoline was estimated to cost \$3,100 per ton of VOC reduced.

FEDERAL RULEMAKING AND/OR GUIDANCE DOCUMENTS

EPA has published several proposals in the *Federal Register* to implement the reformulated gasoline requirements of the CAAA.

On July 9, 1991 (56 FR 31176), the agency proposed two related programs implementing Section 211(k) of the Clean Air Act. The primary program under that section requires that gasoline sold in the nine worst ozone nonattainment areas be reformulated to reduce toxics and ozone-forming VOCs. The second program prohibits gasoline sold in the rest of the United States from becoming more polluting. These regulations are to take effect on January 1, 1995.

On April 16, 1992 (57 FR 13416), EPA published a Supplemental Notice of Proposed Rulemaking (SNPRM) on reformulated gasoline, based upon the provisions of the negotiated agreement signed on August 16, 1991. The SNPRM describes the standards and enforcement scheme for both reformulated gasoline and for conventional gasoline sold in other areas. It also includes specific proposals for the emissions models to be used in gasoline certification and enforcement.

On February 26, 1993 (58 FR 11722), based upon a plan developed by former President Bush, EPA published proposed revisions to the simple model and the contents of the complex model to be used in the certification of reformulated gasoline and associated procedures to assure compliance with the reformulated gasoline and anti-dumping programs. Most significantly, this proposal includes approaches that differ substantially from the unanimous negotiated agreement, such as preferential treatment for

STAPPA/ALAPCO Recommendation

► Areas not already required by the Clean Air Act to implement the federal reformulated gasoline program should opt into the program, provided the final regulations adopted by EPA are consistent with the terms of the agreement reached through the regulatory negotiation. In addition to yielding immediate and significant reductions from all vehicles – new and existing – the federal reformulated gasoline program is inexpensive to the consumer, extremely cost effective and easy to enforce without state and local administrative burden, in that it is a federal program.

Areas that require reductions in addition to those that can be achieved through implementation of the federal reformulated gasoline program may consider adoption of a more aggressive fuel reformulation under Section 211(c)(4). Likewise, for areas that may not require reductions of the magnitude achievable by the federal reformulated gasoline program, Section 211(c)(4) also offers the option of adopting a less effective fuel reformulation.

Areas considering adopting individual fuel reformulations, such as reduced RVP, in lieu of opting into the federal reformulated gasoline program should be aware that they will be required to enforce the program themselves and, therefore, will face enforcement problems that they would not encounter with the federally enforced federal reformulated gasoline program. In addition, such individual fuel reformulation programs will not offer the additional air toxics benefits that will occur under the federal reformulated gasoline program.

ethanol. This notice also proposes phase II reformulated gasoline emissions performance standards that are to take effect in the year 2000, as prescribed by Section 211(k)(3) and authorized by Section 211(c) of the CAAA, as well as a range of NO_x performance standards (with benefits ranging from zero to 8 percent) to complement to the VOC and toxics performance standards.

STATE AND LOCAL CONTROL EFFORTS

States have traditionally led the way in regulating fuel composition to lower emissions. Perhaps the two most significant efforts have been the adoption of reformulated gasoline requirements by California and the adoption of low-RVP requirements by the northeastern states. In addition, all 13 members of the Ozone Transport Region have opted into the federal reformulated gasoline program.

REFERENCES

1. U.S. Environmental Protection Agency, Office of Mobile Sources. July 9, 1991. *Regulation of Fuels and Fuel Additives: Standards for Reformulated Gasoline*. Proposed Rule. 56 *Federal Register* 31176.
2. U.S. Environmental Protection Agency, Office of Mobile Sources. April 16, 1992. *Regulation of Fuels and Fuel Additives: Standards for Reformulated and Conventional Gasoline*. Supplemental Notice of Proposed Rulemaking. 57 *Federal Register* 13416.
3. U.S. Environmental Protection Agency, Office of Mobile Sources. February 26, 1993. *Regulation of Fuels and Fuel Additives: Standards for Reformulated Gasoline*. Proposed Rule. 58 *Federal Register* 11722.

Table 1.....

Standards for Gasoline in California (all standards to take effect in 1996)

	Flat Limit	Averaging Limit	Cap Limit
Reid Vapor Pressure (psi, max.)	7.0	none	7.0
Sulfur (ppmw, max.)	40.0	30.0	80.0
Benzene (vol.%, max.)	1.0	0.8	1.2
Aromatic HC (vol.%, max.)	25.0	22.0	30.0
Olefins (vol.%, max.)	6.0	4.0	10.0
Oxygen (wt.%)	1.8 to 2.2	none	2.7 (max.)
Temperature at 50% distilled (deg. F, max.)	210.0	200.0	220.0
Temperature at 90% distilled (deg. F, max.)	300.0	290.0	330.0

Table 2.....

Baseline VOC and NO_x Emissions (MOBILE4.1 with SNPRM I/M) (gpm)

	Class B	Class C
Summer		
Exhaust VOC emissions	0.446	0.446
Hot soak VOC emissions	0.265	0.230
Diurnal VOC emissions	0.125	0.109
Running loss VOC emissions	0.431	0.390
Refueling VOC emissions	0.040	0.040
Total summer VOC emissions	1.307	1.215
Winter exhaust VOC emissions	0.660	0.660
NO _x emissions	0.660	0.660

Table 3.....

Sample Fuel Compositions

Fuel characteristics	Class C		Class B	
	Fuel 1	Fuel 2	Fuel 3	Fuel 4
Oxygenate	MTBE	EtOH	MTBE	EtOH
Oxygen, weight percent	2.1	2.1	2.1	2.1
Aromatics, volume percent	26.3	24.3	26.2	23.9
Olefins, volume percent	9.2	9.2	9.2	9.2
Benzene, volume percent	0.95	0.95	0.95	0.95
Sulfur, ppm weight	339.0	339.0	339.0	339.0
T50, degrees Fahrenheit	218.0	218.0	218.0	218.0
T90, degrees Fahrenheit	330.0	330.0	330.0	330.0
RVP, pounds per square inch	8.0	8.0	7.1	7.1

Table 4

Simple and Phase I Complex Model
Summer Emissions Reductions of Fuels 1 and 2
In Class C Areas Relative To CAAA Baseline Gasoline

	Simple Model Reductions		Complex Model Reductions	
	Fuel 1	Fuel 2	Fuel 1	Fuel 2
Exhaust VOC	9.9%	9.9%	13.0%	15.4%
Non-Exhaust VOC	23.9%	23.9%	23.9%	23.9%
Total VOC	18.8%	18.8%	19.9%	20.8%
NO _x	0.0%	0.0%	-0.8%	0.1%
Toxics	22.4%	23.4%	22.4%	23.1%

Table 5

Simple and Phase I Complex Model
Summer Emissions Reductions of Fuels 3 and 4
In Class B Areas Relative to CAAA Baseline Gasoline

	Simple Model Reductions		Complex Model Reductions	
	Fuel 3	Fuel 4	Fuel 3	Fuel 4
Exhaust VOC	9.9%	9.9%	14.3%	17.0%
Non-Exhaust VOC	51.4%	51.4%	51.4%	51.4%
Total VOC	37.2%	37.2%	38.7%	39.6%
NO _x	0.0%	0.0%	-2.5%	-2.0%
Toxics	25.7%	27.1%	26.7%	27.9%

Table 6

Simple and Phase I Complex Model
Summer Emissions Reductions of Fuels 3 and 4
In Class B Areas Relative to Class B Baseline Gasoline

	Simple Model Reductions		Complex Model Reductions	
	Fuel 3	Fuel 4	Fuel 3	Fuel 4
Exhaust VOC	9.9%	9.9%	13.2%	15.9%
Non-Exhaust VOC	29.8%	29.8%	29.8%	29.8%
Total VOC	21.3%	21.3%	22.7%	23.8%
NO _x	0.0%	0.0%	-2.5%	-2.0%
Toxics	22.2%	23.7%	17.3%	18.7%

Table 7

Summer Emissions Reductions of Fuels 1 and 2
In Class C Areas Relative to CAAA Baseline Gasoline
Using a Complex Model Based on the Official Version of
MOBILE 5.0

	Complex Model Reductions	
	Fuel 1	Fuel 2
Exhaust VOC	13.1%	15.4%
Non-Exhaust VOC	24.8%	24.8%
Total VOC	17.6%	19.1%
NO _x	-0.8%	0.1%
Toxics	23.2%	23.8%

Table 8

Summer Emissions Reductions of Fuels 3 and 4
In Class B Areas Relative to CAAA Baseline Gasoline
Using a Complex Model Based on the Official Version of
MOBILE 5.0

	Complex Model Reductions	
	Fuel 3	Fuel 4
Exhaust VOC	14.3%	17.0%
Non-Exhaust VOC	49.2%	49.2%
Total VOC	28.9%	30.5%
NO _x	-2.5%	-2.0%
Toxics	27.4%	28.5%

Table 9

Summer Emissions Reductions of Fuels 1 and 2
In Class C Areas Relative to CAAA Baseline Gasoline
Using a Complex Model Based on the Official Version of
MOBILE 4.1

	Complex Model Reductions	
	Fuel 1	Fuel 2
Exhaust VOC	13.0%	15.4%
Non-Exhaust VOC	25.8%	25.8%
Total VOC	21.3%	22.1%
NO _x	-0.8%	0.1%
Toxics	22.9%	23.6%

Table 10

**Summer Emissions Reductions of Fuels 3 and 4
in Class B Areas Relative to CAAA Baseline Gasoline
Using a Complex Model Based on the Official Version of
MOBILE 4.1**

	Complex Model Reductions	
	Fuel 3	Fuel 4
Exhaust VOC	14.3%	17.0%
Non-Exhaust VOC	51.3%	51.3%
Total VOC	39.1%	40.0%
NO _x	-2.5%	-2.0%
Toxics	27.0%	28.3%

Table 11

**Class C Component Control Costs and
VOC Emissions Reductions**

Component	Control Level	Incremental Cost (c/gal)	Cumulative VOC Reduction (%)
Oxygen	2.0 wt%	1.67-3.36 ^a	9.0
Benzene	1.0 vol%	0.69	9.0
RVP	8.1 psi	0.57	17.6
RVP	7.4 psi	1.67	25.3
Sulfur	160 ppm	0.35-0.57	26.4
Oxygen	2.7 wt%	0.59-1.18 ^a	28.5
Olefins	5.0 vol%	1.81-2.44	30.2
Sulfur	50 ppm	1.45-1.86	31.2
Aromatics	20 vol%	0.61-0.98	31.4

^aBased on MTBE. EPA expects ethanol use to be less expensive under its February 26, 1993 proposed revisions to the simple model proposal.

Table 12

**Proposed Standards for Phase II Reformulated Gasoline
(% reduction in emissions)**

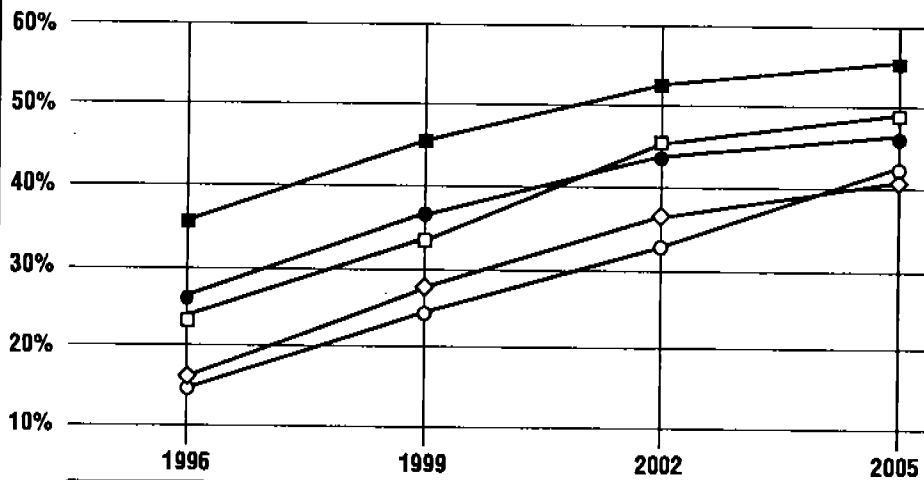
	Cost Effectiveness <\$5,000 per ton		Cost Effectiveness <\$10,000 per ton	
	Class B ^a	Class C	Class B ^a	Class C
A				
VOC Standard	18.5-26.6	25.3-25.3	22.1-30.1	28.5-36.2
B				
NO _x Standard	6.3-7.5	6.3-7.8	14.0-15.0	14.0-15.3
C				
VOC Standard				
w/NO _x Standard	19.7-27.7	26.4-34.0	25.5-33.0	31.2-38.8
D				
Toxics Standard				
From VOC Standard	16.9-21.5	28.4-28.4	23.9-26.3	30.4-32.7

^aClass B standards relative to a Clean Air Act base fuel with RVP at 7.8 psi.

Figure 1

Impact of Fuel Options with Enhanced I/M on VOC Emissions

Percent Reduction From Adjusted 1990 Baseline—Highway Vehicles Only



1996	1999	2002	2005
26.67%	36.72%	43.31%	46.09%
21.99%	32.80%	46.33%	49.34%
36.55%	45.12%	52.36%	55.19%
15.00%	24.00%	33.00%	42.00%
16.79%	28.88%	36.68%	40.25%

- Low RVP Fuel (7.0)
- Federal RFG
- California RFG
- Requirement*
- ◇ Low RVP Fuel (8.1)

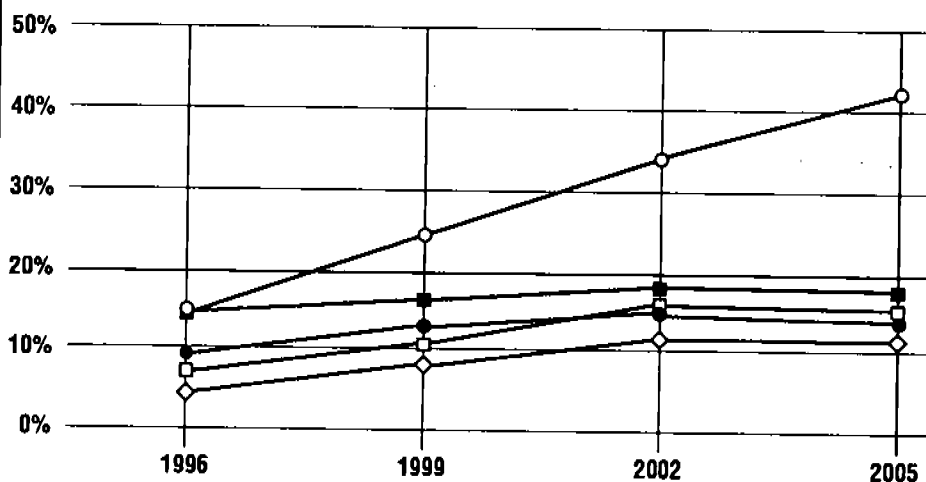
*Assumes proportional reduction from mobile and all other sources

Low RVP Fuel (7.0)
Federal RFG
California RFG
Requirement*
Low RVP Fuel (8.1)

Figure 2

Impact of Fuel Options with Enhanced I/M on VOC Emissions

Percent Reduction From Adjusted 1990 Baseline — Highway and Non-Road Vehicles



1996	1999	2002	2005
9.56%	12.69%	14.11%	13.66%
7.32%	10.81%	15.56%	15.22%
14.28%	16.71%	18.44%	18.02%
15.00%	24.00%	33.00%	42.00%
4.83%	8.93%	10.94%	10.87%

- Low RVP Fuel (7.0)
- Federal RFG
- California RFG
- Requirement*
- ◇ Low RVP Fuel (8.1)

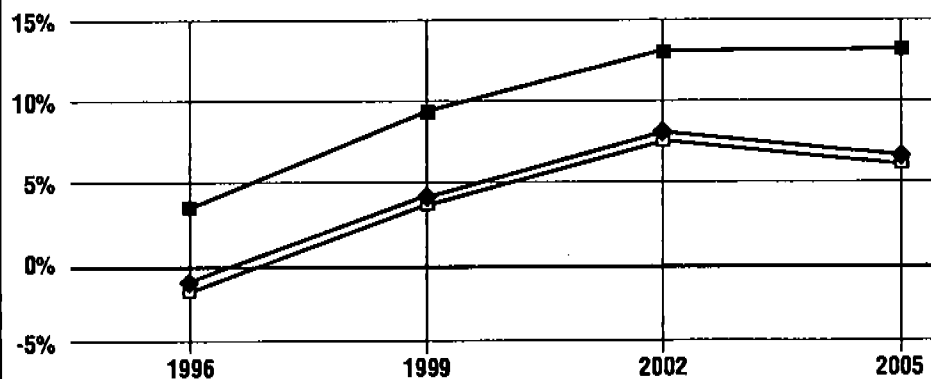
*Assumes proportional reduction from mobile and all other sources

Low RVP Fuel (7.0)
Federal RFG
California RFG
Requirement*
Low RVP Fuel (8.1)

Figure 3

Impact of Fuel Options with Enhanced I/M on NO_x Emissions

Percent Reduction From Adjusted 1990 Baseline — Highway Vehicles Only



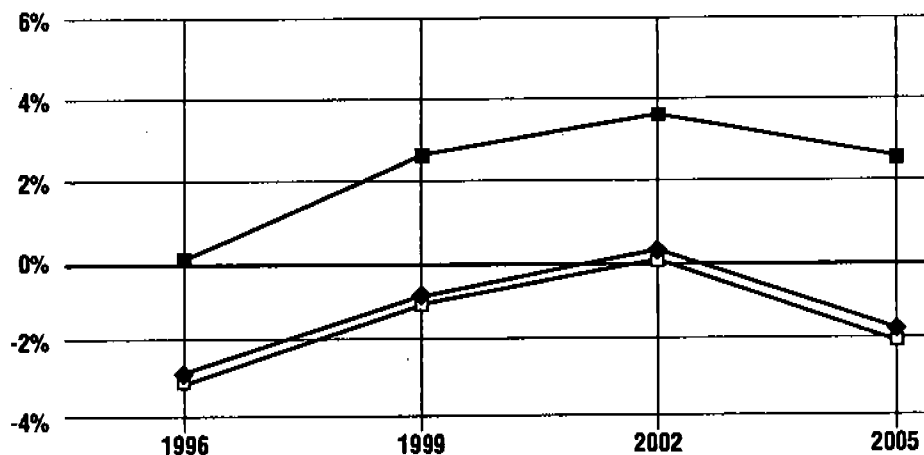
- Low RVP Fuel (7.0)
- Federal RFG
- California RFG
- ◆ Low RVP Fuel (8.1)

Low RVP Fuel (7.0)
Federal RFG
California RFG
Low RVP Fuel (8.1)

Figure 4

Impact of Fuel Options with Enhanced I/M on NO_x Emissions

Percent Reduction From Adjusted 1990 Baseline — Highway and Non-Road Vehicles

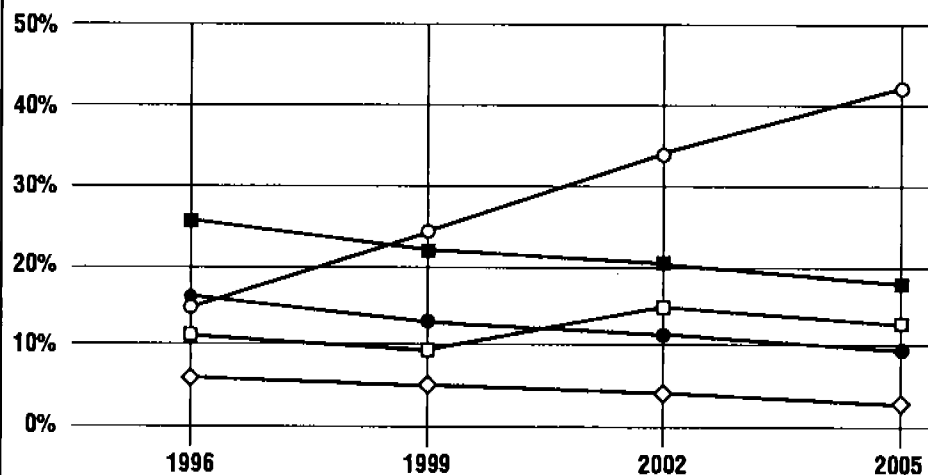


- Low RVP Fuel (7.0)
- Federal RFG
- California RFG
- ◆ Low RVP Fuel (8.1)

Low RVP Fuel (7.0)
Federal RFG
California RFG
Low RVP Fuel (8.1)

Figure 5**Impact of Fuel Options on VOC Emissions**

Percent Reduction From Adjusted 1990 Baseline — Highway Vehicles Only



- Low RVP Fuel (7.0)
- Federal RFG
- California RFG
- Requirement*
- ◇ Low RVP Fuel (8.1)

*Assumes proportional reduction from mobile and all other sources

1996	1999	2002	2005
16.12%	13.44%	11.46%	9.74%
11.44%	9.52%	14.47%	12.99%
26.00%	21.84%	20.51%	18.83%
15.00%	24.00%	33.00%	42.00%
6.24%	5.60%	4.82%	3.90%

Low RVP Fuel (7.0)

Federal RFG

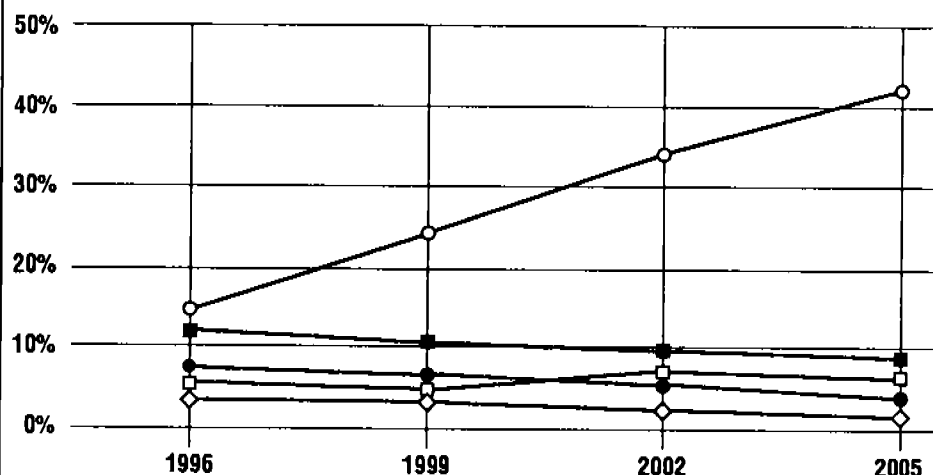
California RFG

Requirement*

Low RVP Fuel (8.1)

Figure 6**Impact of Fuel Options on VOC Emissions**

Percent Reduction From Adjusted 1990 Baseline — Highway and Non-Road Vehicles



- Low RVP Fuel (7.0)
- Federal RFG
- California RFG
- Requirement*
- ◇ Low RVP Fuel (8.1)

*Assumes proportional reduction from mobile and all other sources

1996	1999	2002	2005
7.71%	6.43%	5.48%	4.66%
5.47%	4.56%	6.93%	6.22%
12.44%	10.45%	9.81%	9.01%
15.00%	24.00%	33.00%	42.00%
2.99%	2.68%	2.31%	1.86%

Low RVP Fuel (7.0)

Federal RFG

California RFG

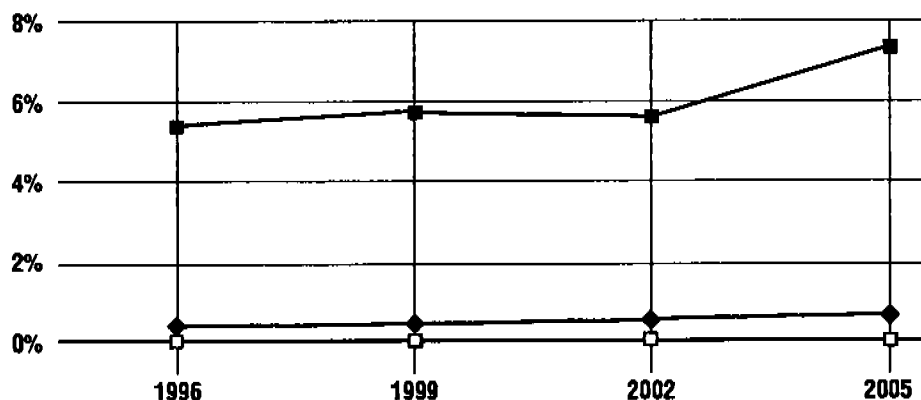
Requirement*

Low RVP Fuel (8.1)

Figure 7

Impact of Fuel Options on NO_x Emissions

Percent Reduction From Adjusted 1990 Baseline — Highway Vehicles Only



- Low RVP Fuel (7.0)
- Federal RFG*
- California RFG
- ◆ Low RVP Fuel (8.1)

*EPA has proposed NO_x reductions of up to 8% for comment

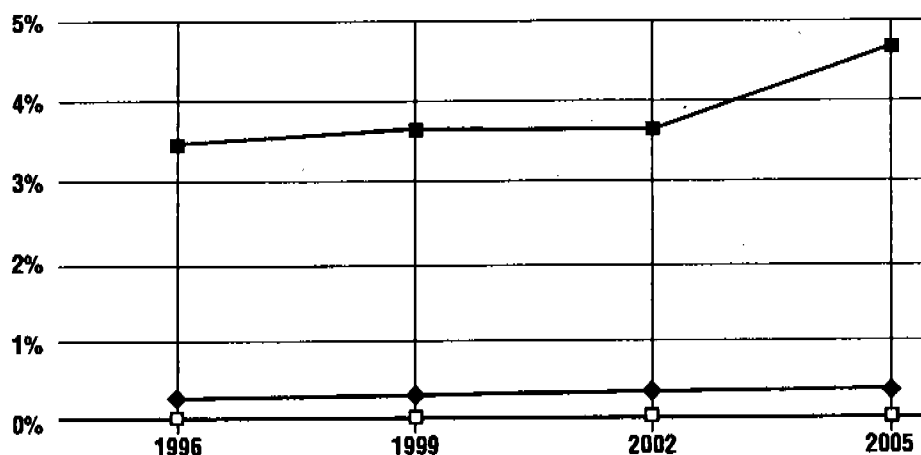
0.45%	0.49%	0.53%	0.57%
0.00%	0.00%	0.00%	0.00%
5.44%	5.85%	5.78%	7.35%
0.45%	0.49%	0.53%	0.57%

Low RVP Fuel (7.0)
Federal RFG*
California RFG
Low RVP Fuel (8.1)

Figure 8

Impact of Fuel Options on NO_x Emissions

Percent Reduction From Adjusted 1990 Baseline — Highway and Non-Road Vehicles



- Low RVP Fuel (7.0)
- Federal RFG*
- California RFG
- ◆ Low RVP Fuel (8.1)

*EPA has proposed NO_x reductions of up to 8% for comment

0.29%	0.31%	0.33%	0.36%
0.00%	0.00%	0.00%	0.00%
3.42%	3.69%	3.64%	4.63%
0.29%	0.31%	0.33%	0.36%

Low RVP Fuel (7.0)
Federal RFG*
California RFG
Low RVP Fuel (8.1)

California Low-Emission Vehicles

DESCRIPTION OF CONTROL MEASURE

Section 177 of the Clean Air Act Amendments of 1990 provides states with authority to adopt, or "opt into," the California low-emission vehicle (LEV) standards, which are substantially more stringent than the federal motor vehicle standards. The LEV program adopted by the California Air Resources Board (CARB), includes light- and medium-duty motor vehicle emissions standards that will reduce emissions from model years 1994 through 2003.

Beginning in 1994, each vehicle may be certified to any one of the sets of standards identified in Table 1. Emissions standards for the transitional low-emission vehicle (TLEV), the low-emission vehicle (LEV), the ultra-low-emission vehicle (ULEV) and the zero-emission vehicle (ZEV) are known collectively as the LEV standards. These standards impose a limit on emissions of non-methane organic gas (NMOG), which differ from non-methane hydrocarbons (NMHC) in that NMOG contains oxygen-bearing compounds, such as aldehydes, in addition to hydrocarbons. In the case of a vehicle certified with conventional (unreformulated) gasoline, the mass emissions of NMOG as directly measured will be compared to the NMOG standards shown in Table 1. For other fuels,

including reformulated gasoline, the mass measured emissions will be adjusted according to reactivity (ozone potentially formed per gram of emissions) before a comparison to the standard is made. As a result, the NMOG standards are equivalent to standards for ozone-forming potential that are of uniform stringency for all fuels.

For any model year after 1993, each manufacturer's vehicle sales in California must be a combination of conventional and low-emission vehicles, such that the average certification standard for NMOG (or NMHC) does not exceed the value identified in Table 2. In addition, 2 percent of each manufacturer's new vehicles in 1998 must be ZEVs; this requirement increases gradually to 10 percent for the 2003 model year.

Recognizing that many vehicles capable of running on an alternative fuel (i.e., a fuel other than gasoline) will also be capable of using gasoline, CARB established auxiliary standards for the "gasoline side" of flexible- or dual-fueled vehicles. Table 3 identifies the NMOG standards for basic certification and for gasoline operation. For example, to be certified as a LEV with an alternative fuel, a vehicle must have reactivity-adjusted NMOG less than 0.075 grams per mile (gpm) with alternative fuel and NMOG less than 0.125 gpm with gasoline. (Prior to 1995, the certify-

ing gasoline must be Indolene, except for LEVs. After 1995, the certifying gasoline may be either CARB's Phase 2 reformulated gasoline or Indolene. For Phase 2 reformulated gasoline, actual measured NMOG will be reactivity-adjusted to the Indolene basis before comparison with the NMOG standard for gasoline operation.)

The effectiveness of emissions standards can be substantially affected by the manner in which they are enforced. Beyond more stringent standards, the California LEV program has been distinguished by a consistent move toward greater manufacturer responsibility for in-use emissions.

For example, under the California program, defect reporting and recall is a specific requirement. Beginning with the 1990 model year, CARB regulations require manufacturers to report all warranty claims for emissions-related components that occur at a rate of 4 percent or more. Unless the manufacturer can show that the true failure rate is below these reporting thresholds or that the emissions impact is negligible, a recall of the vehicles using the failing components is required.

When a recall is required, the minimum acceptable success rate is 60 percent (for voluntary recalls). If the recall is ordered by CARB, the required success rate is increased to 80 percent. By comparison, only about 55 percent of cars recalled under the federal program are actually repaired, although, under the new requirements, in areas implementing enhanced I/M, 100 percent of recalled vehicles will be required to be repaired.

AVAILABLE CONTROL STRATEGIES

Under MOBILE5a, the benefits associated with adoption of the California LEV program are dependent upon the type of motor vehicle Inspection and Maintenance (I/M) program adopted and the type of fuel used. Accordingly, three alternative scenarios were modeled. In the first, the LEV program is adopted for the 1996 model year, along with enhanced I/M and federal reformulated gasoline. In the second, LEV is coupled with an "appropriate" I/M program and federal reformulated gasoline; and in the third, LEV is combined with the simultaneous adoption of "appropriate" I/M and California reformulated gasoline.

POTENTIAL NATIONAL EMISSIONS REDUCTION

Figures 1 through 5 illustrate the emissions reduction potential of each of the above options. It is clear that the LEV program is capable of yielding additional reductions in both VOC and NO_x emissions, especially in the long term.

A distinguishing characteristic of the LEV strategy is that it is also capable of significant NO_x reductions. For example, if implemented with "appropriate" I/M and federal reformulated gasoline, the NO_x increase by 1996 is diminished to only 1 percent; further, by 1999 NO_x is reduced by 7 percent and in 2002 and 2005 by 18 percent.

The incremental benefits of LEVs compared to federal Tier 1 vehicles are also significant, as illustrated in Figure 5. This figure depicts the incremental LEV emissions reductions for highway vehicle VOCs and NO_x, assuming that each has the same I/M program (either enhanced or "appropriate") or comparing LEV coupled with "appropriate" I/M to Tier 1 combined with enhanced I/M.

While the incremental benefits of LEV versus Tier 1 vehicles are significant, even assuming enhanced I/M, this scenario would seem to understate the potential benefits of LEV vehicles by applying an I/M program that does not account for the lower in-use potential of LEV vehicles. To address this, EPA developed a concept of "appropriate" I/M. "Appropriate" I/M consists of an annual or biennial program, performed in a test-only format, based upon the IM240 transient emission test with a specific set of age-based cutpoints (nominally 50-percent higher than the certification standards) and including onboard diagnostic system interrogation for emission control system fault codes, with vehicles repaired as indicated by these codes. (Please note that use of the term "appropriate" is not intended to imply that EPA considers this the appropriate I/M case for these vehicles.)

"Appropriate" I/M was originally conceived as a mechanism to assure EPA that the lower deterioration rate that CARB estimated for vehicles in the LEV program compared to Tier 1 vehicles would, in fact, occur. EPA subsequently included the same low deterioration rates as an option in the MOBILE model. It should be noted that California has greater authority than EPA to change the design of its compliance program if necessary to help achieve this goal if LEVs do not, in fact, have lower deterioration rates than federal vehicles. Consequently, it is questionable whether the "paper" emissions reductions that result when adoption of "appropriate" I/M with federal vehicles is modeled will actually materialize. Therefore, a comparison of LEV and Tier 1 vehicles assuming that both implement "appropriate" I/M likely overstates the benefits of Tier 1 vehicles.

Several of the states that are furthest along in their consideration of the LEV program have concluded that the most accurate comparison for the purpose of determining the likely benefits of LEV is one which compares LEV combined with "appropriate" I/M to Tier 1 vehicles with enhanced I/M.

As illustrated in Figure 5, under this scenario, LEV benefits compared to Tier 1 vehicles increase rapidly from 1996 on and are 10 percent and 19 percent, respectively, for VOC and NO_x by 2005 and continue to increase thereafter.

COST EFFECTIVENESS

As illustrated in Figure 6, the LEV standards are very cost effective. The first two bars for each scenario in the figure are based upon the emissions reductions calculated in the preceding section and CARB's original estimates of an incremental cost of \$70 per vehicle to achieve the TLEV and LEV standards and \$170 to achieve the ULEV standards. More recent data, however, indicate that these costs are likely to be on the high end of the range. CARB has recently noted that technology is advancing more quickly than previously anticipated, with the result being a continuing decline in costs. CARB's new assessment concludes that the costs of TLEV, LEV and ULEV vehicles will be only \$18.75, \$59.50 and \$127.75, respectively. These costs are reflected in the two additional bars for each scenario in the figure. It should be noted that the auto industry strongly contests these estimates, arguing that the costs will be much higher and the emissions reductions much lower.

STATE AND LOCAL CONTROL EFFORTS

Several states, particularly in the northeast, have made significant progress toward adoption of the California LEV program. New York, Massachusetts, Maine and New Jersey have adopted the program, although, under intense pressure from the auto industry, the Maine legislature subsequently placed its program on hold, while, the industry has challenged the New York and Massachusetts programs in court. The Maryland legislature has also adopted the LEV program and the remaining states in the Northeast Ozone Transport Commission have committed to eventual adoption as well. Texas and Wisconsin are also considering the program.

Both the Northeast States for Coordinated Air Use Management and the Mid-Atlantic Regional Air Management Association have published comprehensive evaluations of implementation of the LEV program in their areas.

REFERENCES

1. California Air Resources Board, Tom Cackette. May 5, 1993. *Progress in Implementing California's Low-Emission Vehicle Program*.

STAPPA/ALAPCO Recommendation

► While adoption of the California LEV program will not have a large impact by 1996, especially for states that have not yet adopted the program, it does have the potential to yield a substantial benefit over time, particularly in the post 2000 time-frame, when additional mobile source emissions reductions will be difficult to obtain. Further, the LEV program will be especially helpful to those areas that will need additional NO_x controls to reduce levels of ozone.

2. Mid-Atlantic Regional Air Management Association. December 1992. *Adopting the Low-Emission Vehicle Program in the Mid-Atlantic States*.
3. Northeast States for Coordinated Air Use Management. September 1991. *Adopting the Low-Emission Vehicle Program in the Mid-Atlantic States: An Evaluation*.

Table 1.....
50,000-Mile Certification Standards
(gpm)

CATEGORY	NMHC	NMOG ^a	CO	NO _x
Conventional	0.25	—	3.4	0.4
TLEV	—	0.125	3.4	0.4
LEV	—	0.075	3.4	0.2
ULEV	—	0.040	1.7	0.2
ZEV	—	0	0	0

^aThe standard applies to emissions that have been reactivity-adjusted to the gasoline basis.

Table 2

**Fleet Average Standards for NMOG
for Passenger Cars and Light-Duty Trucks
(gpm)**

Model Year	Fleet Average Standard for NMOG ^a
1994	0.250
1995	0.231
1996	0.225
1997	0.202
1998	0.157
1999	0.113
2000	0.073
2001	0.070
2002	0.068
2003	0.062

^aThe standard applies to emissions that have been reactivity-adjusted to the gasoline basis.

Table 3

**NMOG Standards for Flexible- and Dual-Fueled
Passenger Cars Operating on an Alternative Fuel and
Gasoline at 50,000 Miles
(gpm)**

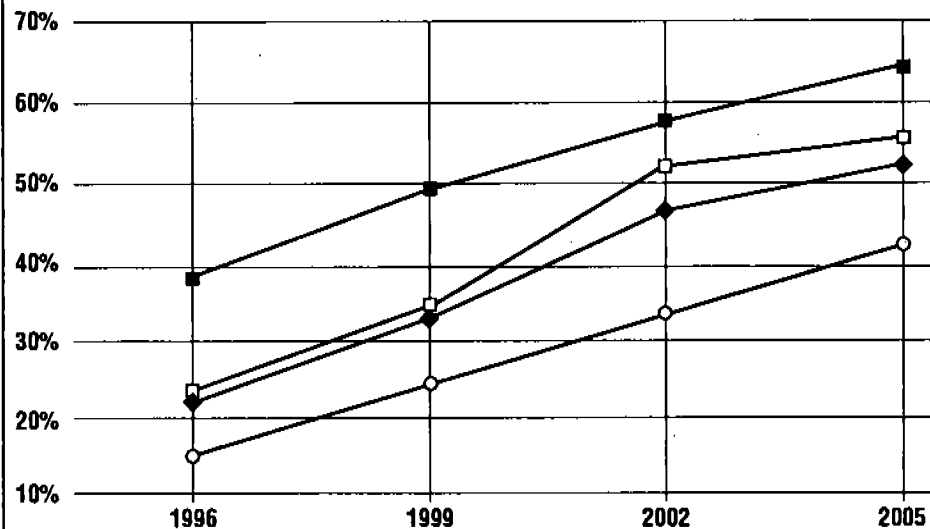
Category	Alternate Fuel ^a	Gasoline
TLEV	0.125	0.250
LEV	0.075	0.125
ULEV	0.040	0.075

^aThe standard applies to emissions that have been reactivity-adjusted to the gasoline basis.

Figure 1

Impact of LEV Options on VOC Emissions

Percent Reduction From Adjusted 1990 Baseline — Highway Vehicles Only



- ◆ Enhanced I/M, FRFG
- App. I/M, FRFG
- App. I/M, California RFG
- Requirement*

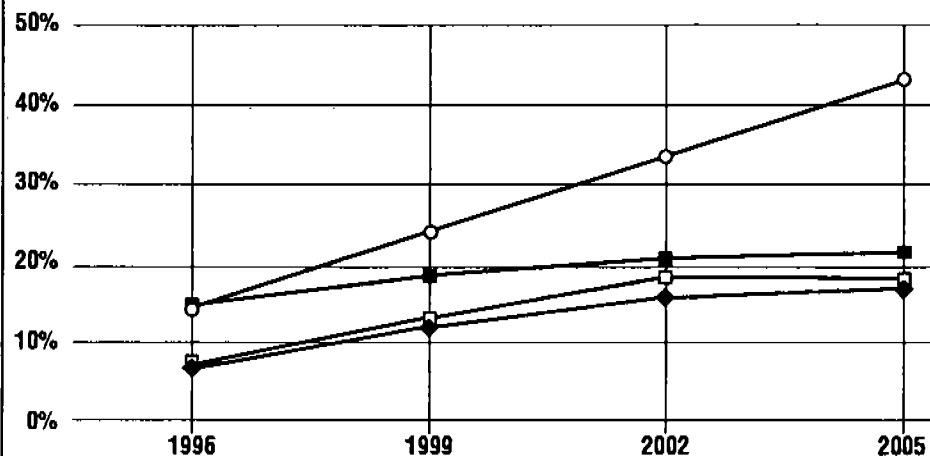
*Assumes proportional reduction from mobile and all other sources

Enhanced I/M, FRFG
App. I/M, FRFG
App. I/M, California RFG
Requirement*

Figure 2

Impact of LEV Options on VOC Emissions

Percent Reduction From Adjusted 1990 Baseline — Highway and Non-Road Vehicles



- ◆ Enhanced I/M, FRFG
- App. I/M, FRFG
- App. I/M, California RFG
- Requirement*

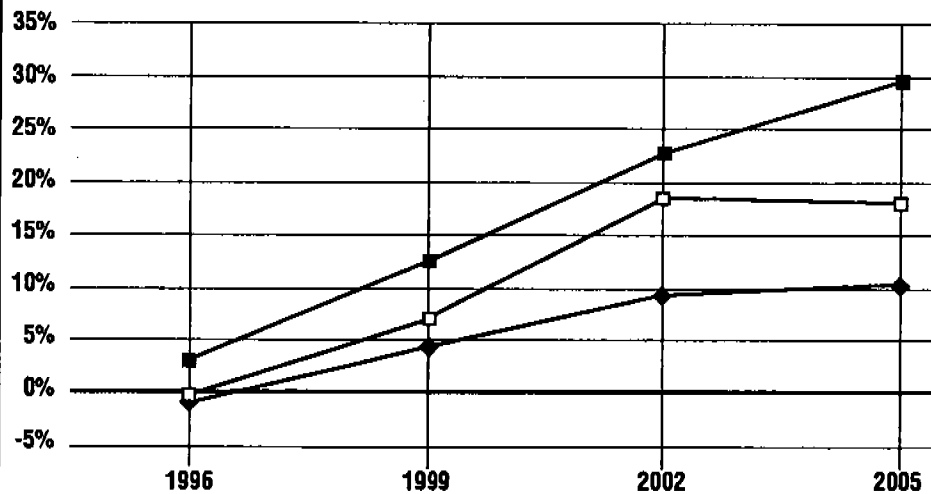
*Assumes proportional reduction from mobile and all other sources

Enhanced I/M, FRFG
App. I/M, FRFG
App. I/M, California RFG
Requirement*

Figure 3

Impact of LEV Options on NO_x Emissions

Percent Reduction From Adjusted 1990 Baseline — Highway Vehicles Only



1996	1999	2002	2005
-1.47%	4.38%	9.64%	10.61%
-1.02%	7.31%	18.05%	17.97%
3.96%	12.68%	22.77%	29.85%

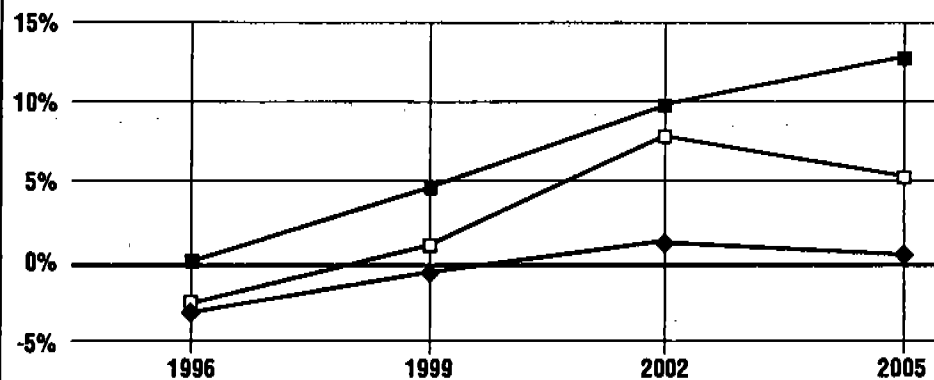
- ◆ Enhanced I/M, FRFG
- App. I/M, FRFG
- App. I/M, California RFG

Enhanced I/M, FRFG
App. I/M, FRFG
App. I/M, California RFG

Figure 4

Impact of LEV Options on NO_x Emissions

Percent Reduction From Adjusted 1990 Baseline — Highway and Non-Road Vehicles



1996	1999	2002	2005
-3.20%	-0.71%	1.38%	0.73%
-2.92%	1.14%	6.67%	5.36%
0.22%	4.52%	9.65%	12.84%

- ◆ Enhanced I/M, FRFG
- App. I/M, FRFG
- App. I/M, California RFG

Enhanced I/M, FRFG
App. I/M, FRFG
App. I/M, California RFG

Figure 5

Incremental Benefits of LEV Over Tier I

Percent Reductions in Emissions — Highway Vehicles Only with Federal Reformulated Gasoline

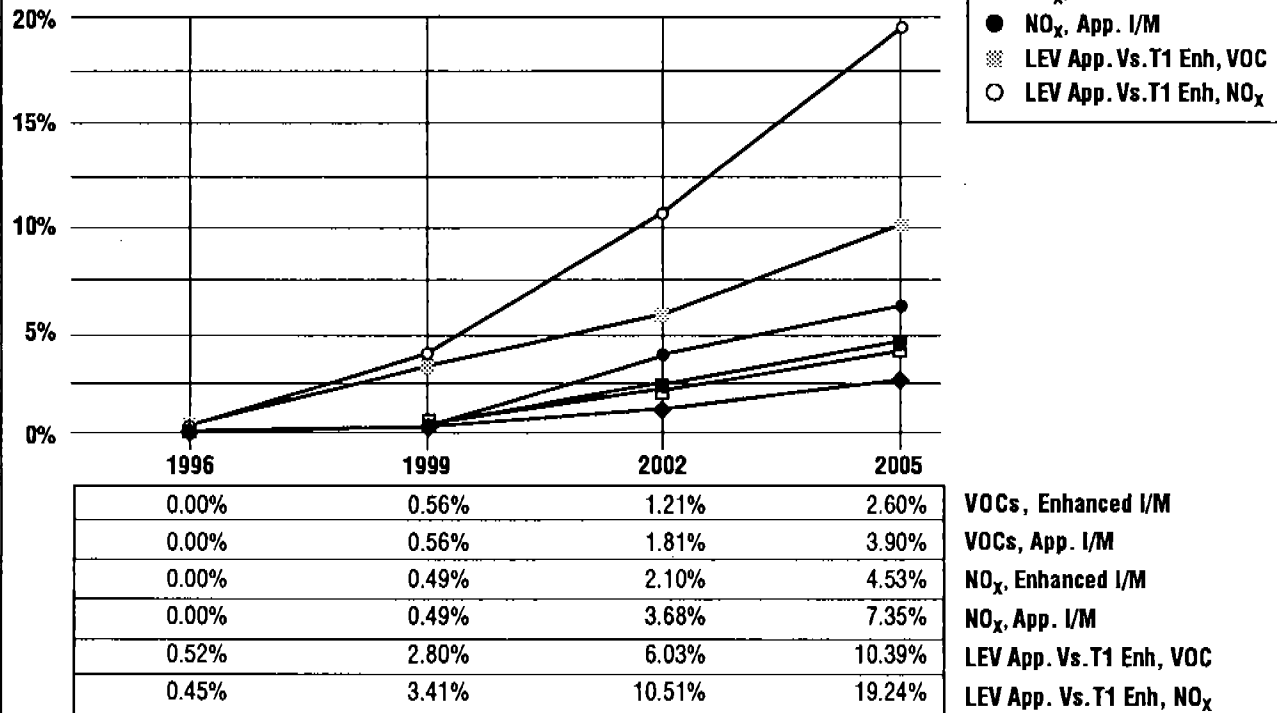
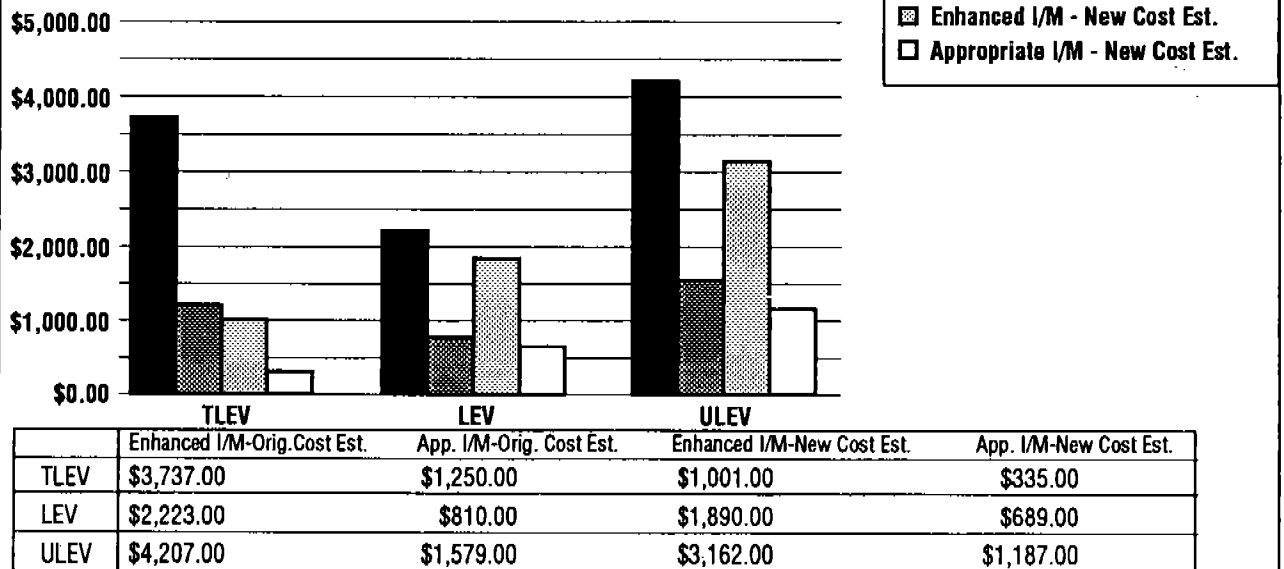


Figure 6

Cost Effectiveness of LEV Program

\$/Ton of VOC Removed



Clean-Fuel Fleets

DESCRIPTION OF CONTROL MEASURE

Provisions of the Clean Air Act Amendments of 1990 (CAAA) require the establishment of a clean-fuel fleet program in certain ozone and carbon monoxide nonattainment areas. Accordingly, 22 areas in 19 states are obligated to modify their State Implementation Plans (SIPs) to require that some of the new vehicles purchased by certain fleet owners meet clean-fuel fleet vehicle (CFFV) exhaust emissions standards. Under the CAAA, a clean fuel is defined as any fuel, including any gasoline or diesel, that will allow the vehicle to achieve mandated emissions standards. In addition, the U.S. Environmental Protection Agency (EPA) has established a subgroup of CFFVs, known as inherently low-emission vehicles (ILEVs). This federal program, which is voluntary for both vehicle manufacturers and the fleet industry, grants expanded exemptions from transportation control measures (TCMs) to ILEVs in recognition of their superior emission characteristics. Initially, ILEVs will receive exemptions from high-occupancy vehicle (HOV) lane restrictions; EPA has announced that it will propose additional exemptions/incentives later this year. These exemptions are intended to provide further incentives to fleet owners to purchase

cleaner vehicles than otherwise required by the statute.

Section 246(b) of the CAAA directs states that contain areas subject to the CFFV program to require that "at least a specified percentage of all new covered fleet vehicles in model year 1998 and thereafter purchased by each covered fleet operator in each covered area shall be clean-fuel vehicles and shall use clean alternative fuels when operating in the covered area." The 19 states that contain affected areas are required to revise their SIPs to include programs that ensure that covered fleet owners meet this purchase requirement when they acquire vehicles for their fleets. Regulated fleet owners will retain discretion regarding other choices about vehicle purchases, such as the fuel technology of the vehicles.

A CFFV is one that meets any one of three sets of CFFV exhaust emissions standards. The emissions standards and the vehicles that meet them are referred to as low-emission vehicles (LEVs), ultra-low-emission vehicles (ULEVs) and zero-emission vehicles (ZEVs). Only LEVs are required to be purchased under the statute; affected fleet operators purchasing ULEVs and ZEVs in lieu of LEVs will receive purchase credits against the CFFV purchase requirements. Three vehicle classes are covered by the program: light-duty vehicles and trucks (LDVs and LDTs)

under 6,000 lbs Gross Vehicle Weight Rating (GVWR); LDTs between 6,000 lbs and 8,500 lbs GVWR; and heavy-duty vehicles (HDVs) over 8,500 lbs GVWR, but under 26,000 lbs GVWR.

The CAAA prescribe purchase requirements in terms of a percentage of the total number of new covered fleet vehicles of each class purchased each year by an affected fleet operator. The purchase requirements begin with model year 1998 vehicles. For light-duty vehicles and light-duty trucks, this date may be extended by up to three years if the appropriate vehicles are not available for sale in California. The program's purchase requirements are phased in over three years. Two phase-in schedules are specified, one for LDVs and LDTs and one for HDVs, as shown below.

Vehicle Purchase Requirement Phase-In Rate

Vehicle Class	Model Year 1998	Model Year 1999	Model Year 2000
LDVs/LDTs	30%	50%	70%
HDVs	50%	50%	50%

The requirements of this program can be met by purchasing new vehicles that meet the CFFV LEV, ULEV or ZEV standards or by converting conventional vehicles to CFFVs that meet the applicable standards.

There are currently 22 covered areas in 19 states affected by the CFFV program; these areas are identified in Table 1. At this time, the only affected carbon monoxide (CO) nonattainment area that is not also classified as an ozone nonattainment area, based on 1987-1989 data, is the Denver-Boulder, Colorado area.

AVAILABLE CONTROL STRATEGIES

A state may reduce emissions not only by requiring the purchase of the necessary CFFVs, but also by encouraging the purchase of more CFFVs than required in any year, the purchase of vehicles that meet stricter emission standards than those required or the advance purchase of vehicles, before requirements take effect. States may also encourage non-covered fleets to participate.

The incorporation of ILEVs into the CFFV program will result in additional hydrocarbon (HC) reductions, due to the lower evaporative emissions from ILEVs. According to MOBILE5a, evaporative emissions constitute a substantial fraction of HC emissions from current vehicles, both because of conditions that overload the evaporative canister and because of in-use failures of various components of the evaporative control system (e.g., leaking vapor hoses and malfunctioning purge valves). Because of the inherent

properties of the fuel or the fuel system design, ILEVs will not have significant evaporative emissions, even if the evaporative emissions control system fails. Therefore, to the extent that ILEVs replace conventional-fuel vehicles, in-use evaporative hydrocarbon emissions will decrease substantially and, in some cases, will be eliminated entirely.

In order to achieve additional nitrogen oxides (NO_x) reductions for the purposes of ozone control and to encourage low- NO_x technology development, the ILEV NO_x standard is the same as the LEV and ULEV NO_x standard.

Vehicle models that manufacturers wish to certify as ILEVs must meet two primary criteria. First, the vehicle's engine/fuel systems must be certified to meet the ILEV non-methane organic gas (NMOG) evaporative emissions standard; second, the vehicle must meet the ILEV exhaust emissions standards (identified in Tables 2 and 3). The ILEV evaporative emissions standard of 5 grams per test must be met without the use of any auxiliary emission control devices to reduce or control evaporative emissions (e.g., carbon canister, purge system). In order to prevent a slow fuel leak from continuing over time, a manufacturer must certify in its application for certification that the vehicle meets the requirements for closed fuel systems. For closed fuel systems, which are often pressurized, the design must be such that a leak into the atmosphere anywhere within the fuel system would render the vehicle inoperative through a relatively quick loss of fuel supply. This requirement not only recognizes the contribution of leaks to emissions, but also acknowledges that substantial fuel loss makes repair necessary for continued operation, thus reducing the likelihood that emissions from leaks would go unrepaired for a substantial amount of time. These test criteria for ILEVs ensure that even if the vehicle develops an evaporative control system malfunction in use, production of evaporative HC emissions in total (hot soak, diurnal, and running loss) by ILEVs will be at a level substantially below the average of their non-ILEV counterparts.

Based upon limited data, EPA projects that the 5-gram evaporative standard will permit vehicles that operate on very low-volatility fuels (such as pure ethanol and pure methanol), as well as pressurized gaseous fuels (natural gas [CNG], liquefied petroleum gases [LPG] and hydrogen), to potentially qualify as ILEVs. In addition, it is expected that dedicated electric vehicles would meet the ILEV evaporative emissions standard. EPA believes that vehicles operating on some formulations of petroleum fuels may also meet the ILEV standard and would therefore qualify as ILEVs.

The ILEV program is limited to dedicated-fuel vehicles and dual-fuel vehicles that are certified as ILEVs on

STAPPA/ALAPCO Recommendation

► Areas not required by the CAAA to implement a CFFV program should consider adoption of such a program.

To increase the reduction potential of a CFFV program, areas already required to implement such a program may wish to consider requiring the purchase of more CFFVs than required in any year, the purchase of vehicles that meet stricter emission standards than those required or the advance purchase of vehicles, before requirements take effect. States may also encourage non-covered fleets to participate.

both fuels. Due to the critical role of the fuel in the emissions of the vehicle, and the difficulty of enforcement, flexible-fuel and dual-fuel vehicles that do not qualify as an ILEV on all possible fuels and fuel combinations can not be considered ILEVs.

It is important to note that there is a parallel alternative fuels program mandated by the Energy Policy Act of 1992. Under this law, federal fleets are required to phase in alternative fuels in their new purchases beginning in 1993. As illustrated in Figure 1, President Clinton has issued an Executive Order increasing the federal fleet purchase requirements by 50 percent between 1993 to 1995. Beyond this timeframe, federal, state, municipal, private and fuel provider alternative fuel fleet purchase requirements increase significantly. As a result, it is likely that fueling facilities for alternative fueled vehicles will begin to be more widely available, increasing the viability of alternative fuel and ILEV vehicles.

POTENTIAL NATIONAL EMISSIONS REDUCTION

EPA has not yet precisely defined the credits available for ILEV vehicles, although they have estimated that the conversion of 25 percent of the fleet vehicles to ILEVs in a given area should reduce mobile source VOCs by approximately 1 percent.

For the purposes of this document, MOBILE5a was used to estimate the possible reductions that could occur from two alternatives: 1) the purchase of 10,000 CFFVs in 1996 meeting either LEV, ULEV, ZEV or ILEV requirements and 2) the purchase of 10,000 vehicles per year beginning in 1996 meeting either LEV, ULEV, ZEV or ILEV requirements.

For each case, two alternative I/M programs were modeled – enhanced and “appropriate.”

The results, presented as tons reduced on a typical summer day, are summarized in Figures 2 through 9. As illustrated, the benefits of purchasing 10,000 vehicles in 1996 are modest, but not insignificant. ILEVs and ZEVs will provide greater credits than LEVs or ULEVs and the overall benefits are higher with “appropriate” I/M than with enhanced I/M.

If 10,000 vehicles per year were to be purchased beginning in 1996, the benefits would increase rapidly and would be quite significant, especially for ZEVs and ILEVs.

In both of the above scenarios, ZEVs were assumed to emit zero emissions. While the vehicles themselves would have no emissions, it is generally agreed that emissions from power plants providing electricity for ZEVs should be allocated to these vehicles. These per-vehicle emission factors will vary depending upon the mix of power plant fuels used in a given state or region. Emission factors will also vary depending upon the vehicle's battery technology and physical characteristics. An assessment of these issues was carried out for the northeast region by the Northeast States for Coordinated Air Use Management, with resulting emissions factors summarized in Table 4.

COST EFFECTIVENESS

For the purposes of evaluating the CFFV program, the cost effectiveness of the various LEV categories should be similar to those estimated for the California LEV program.

FEDERAL RULEMAKING AND/OR GUIDANCE DOCUMENTS

On June 10, 1993, EPA published a proposed rule addressing clean-fuel fleet emissions standards, conversions, averaging and accounting procedures for banking and trading credits (58 *Federal Register* 32474).

STATE AND LOCAL CONTROL EFFORTS

Most current CFF initiatives are pilot programs designed primarily to assess the viability of alternative-fueled vehicle technology for various applications; most provide little in

the way of emissions benefits. The compressed natural gas program being implemented in Texas, however, is an example of a broadly applicable strategy potentially capable of providing additional emissions reductions.

In 1989, following a one-year pilot demonstration project, the Texas legislature mandated a phase in of clean-fuel vehicles for fleets in nonattainment areas. Effected fleets include public transit buses, state agencies and school districts with fleets of more than 50 school buses. Vehicles purchased by effected fleets must be clean-fueled. Compliance targets are 30 percent of affected fleets by September 1, 1994; 50 percent by 1996; and 90 percent by 1998. The legislation also empowers the Texas Air Control Board to establish mandates for local government fleets of greater than 15 vehicles and for private fleets of more than 25 vehicles. Vehicles in these fleets must have the capability of operating on compressed natural gas or other alternative fuels with comparable emissions characteristics.

REFERENCES

1. U.S. Environmental Protection Agency, Office of Mobile Sources. June 10, 1993. *Clean Fuel Fleet Emission Standards, Conversions, and General Provisions and Amended Heavy Duty Averaging, Banking and Trading Credit Accounting Regulations*. Proposed Rule. 57 *Federal Register* 32474.
2. U.S. Department of Energy, Office of Transportation Technologies. May 1993. *Clean Cities Program Plan*.
3. Office of the President. April 21, 1993. *Executive Order 12844: Federal Use of Alternative Fueled Vehicles*.

Table 1.....

Areas and States Affected by the Clean-Fuel Fleet Program

Affected Area:	Affected State(s):
1. Atlanta	Georgia
2. Baltimore	Maryland
3. Baton Rouge	Louisiana
4. Beaumont-Port Arthur	Texas
5. Boston-Lawrence-Worcester (Eastern Massachusetts)	Massachusetts, New Hampshire
6. Chicago-Gary-Lake County	Illinois, Indiana
7. Denver-Boulder	Colorado
8. El Paso	Texas
9. Greater Connecticut	Connecticut
10. Houston-Galveston-Brazoria	Texas
11. Los Angeles-South Coast Air Basin	California
12. Milwaukee-Racine	Wisconsin
13. New York-Northern New Jersey-Long Island	Connecticut, New Jersey, New York
14. Philadelphia-Wilmington-Trenton	Delaware, Maryland, New Jersey, Pennsylvania
15. Providence (All Rhode Island)	Rhode Island
16. Sacramento	California
17. San Diego	California
18. San Joaquin Valley	California
19. Southeast Desert Modified Air Quality Management District	California
20. Springfield (Western Massachusetts)	Massachusetts
21. Ventura County	California
22. Washington, DC	Maryland, Virginia, District of Columbia

Table 2.....
**Light-Duty ILEV Exhaust Emission Standards
(gpm)**

Vehicle/Engine Class/Subclass Miles	NMOG	CO	NO _x	PM	HCHO
Light-duty Vehicles					
50,000	0.075	3.4	0.2	—	0.015
100,000	0.090	4.2	0.3	0.08	0.018
LDTs, 0-6000 lbs GVWR, 0-3750 lbs Loaded Vehicle Weight (LVW)					
50,000	0.075	3.4	0.2	—	0.015
100,000	0.090	4.2	0.3	0.08	0.018
LDTs, 0-6000 lbs GVWR, 3751-5750 lbs LVW					
50,000	0.100	4.4	0.4	—	0.018
100,000	0.130	5.5	0.5	0.08	0.023
LDTs, over 6000 lbs GVWR, 0-3750 lbs TW					
50,000	0.125	3.4	0.2	—	0.015
120,000	0.180	5.0	0.3	0.08	0.022
LDTs, over 6000 lbs GVWR, 3751-5750 lbs TW					
50,000	0.160	4.4	0.4	—	0.018
120,000	0.230	6.4	0.5	0.10	0.027
LDTs, over 6000 lbs GVWR, 5751-8500 lbs TW					
50,000	0.195	5.0	0.6	—	0.022
120,000	0.280	7.3	0.8	0.12	0.032

Table 3.....
**Heavy-Duty ILEV Exhaust Emission Standards
(grams/brake-horsepower-hour)**

Vehicle/Engine Class/Subclass Miles	NMHC + NO _x	CO	PM	HCHO
Heavy-duty engines				
See 40 CFR 86.090-2	2.5	14.4	0.10	0.05

Table 4
ZEV Emission Factors

	2000	2005	2010	2015
Efficiency Rating (kilowatt-hours/mile)	.35	.24	.24	.24
VOC (gpm)	0.005	0.003	0.003	0.003
NO _x (gpm)	0.15	0.11	0.14	0.14
CO (gpm)	0.06	0.04	0.04	0.04
SO ₂ (gpm)	1.35	0.60	0.37	0.37

Figure 1

Federal Fleet Purchase Requirements for Alternative Fuel Vehicles Environmental Policy Act of 1992 Versus Executive Order

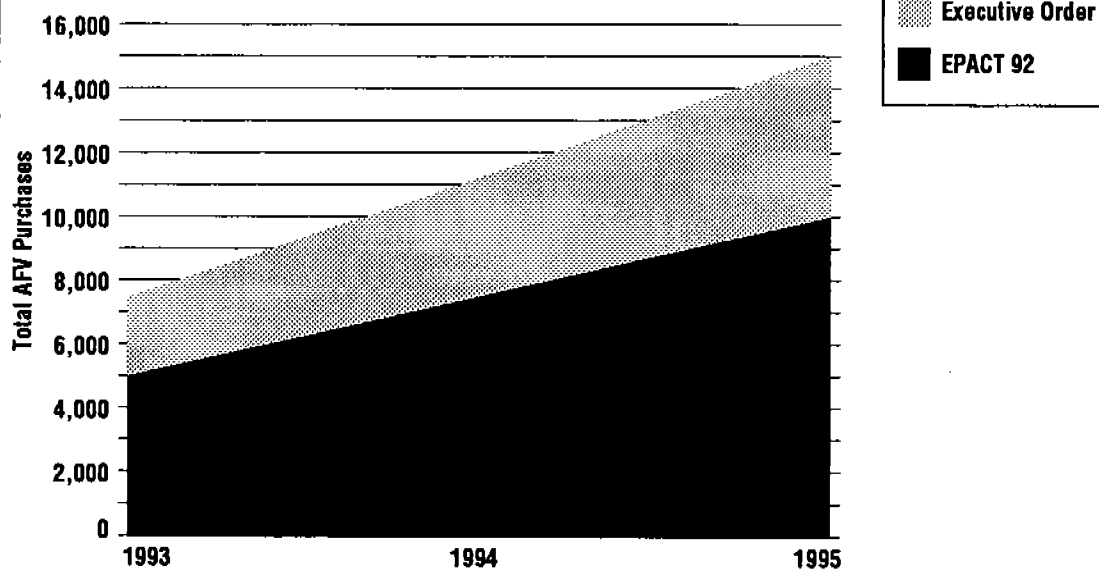


Figure 2

VOC Benefits of CFFV Program with 10,000 Vehicles and "Appropriate" I/M

Tons Per Day

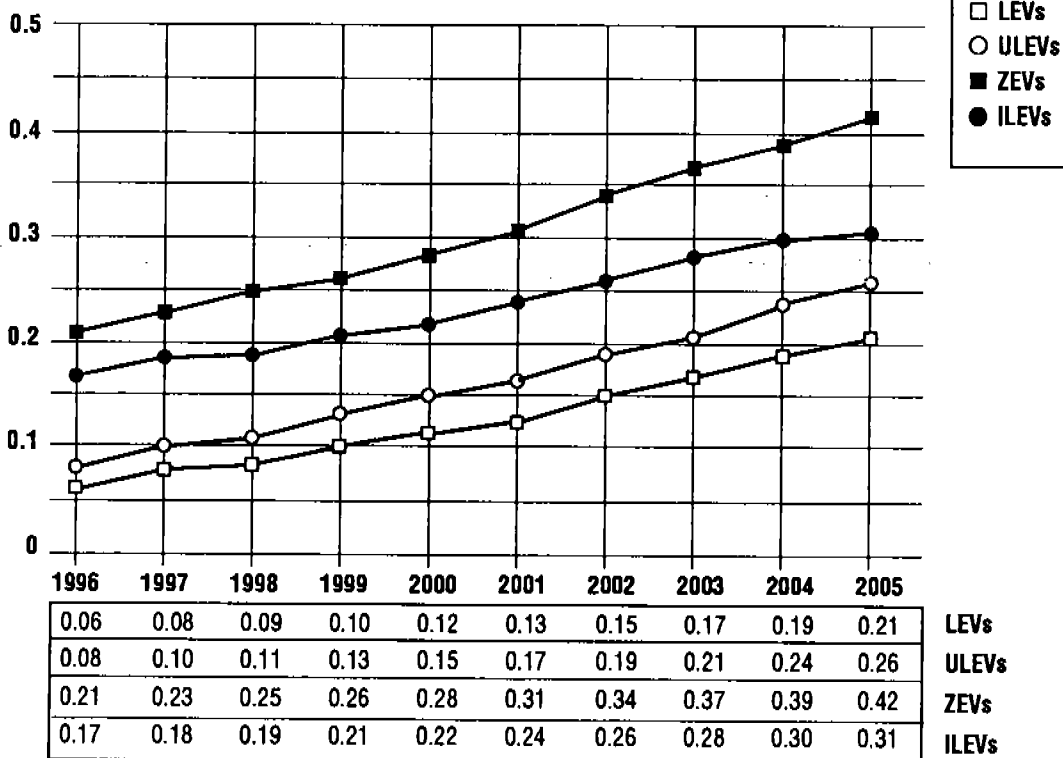


Figure 3

NO_x Benefits of CFFV Program with 10,000 Vehicles and "Appropriate" I/M

Tons Per Day

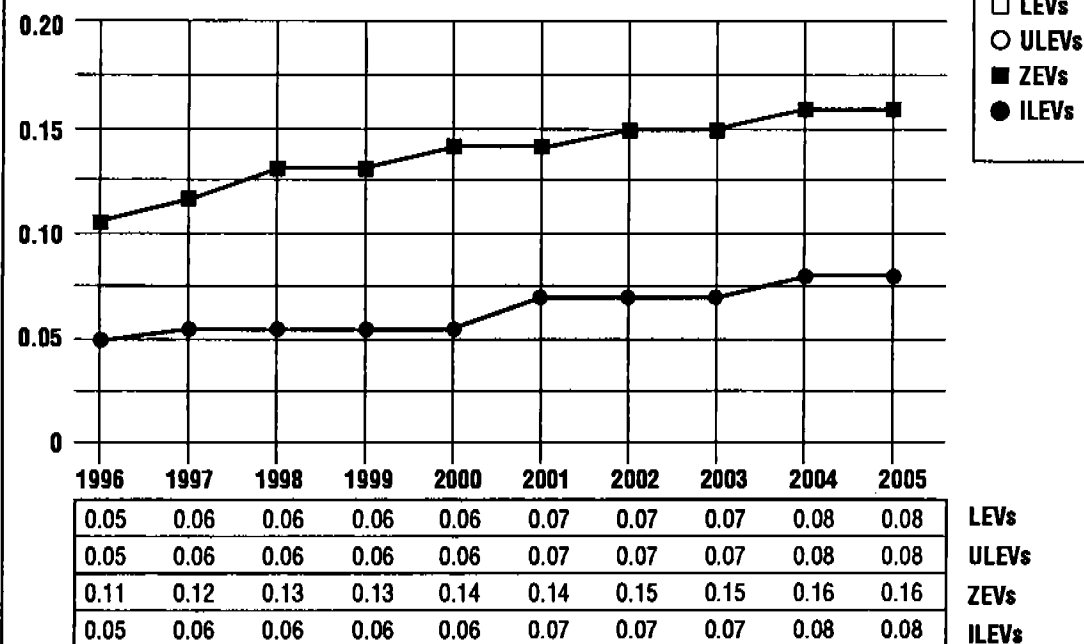


Figure 4

VOC Benefits of CFFV Program with 10,000 Vehicles Per Year and "Appropriate" I/M

Tons Per Day

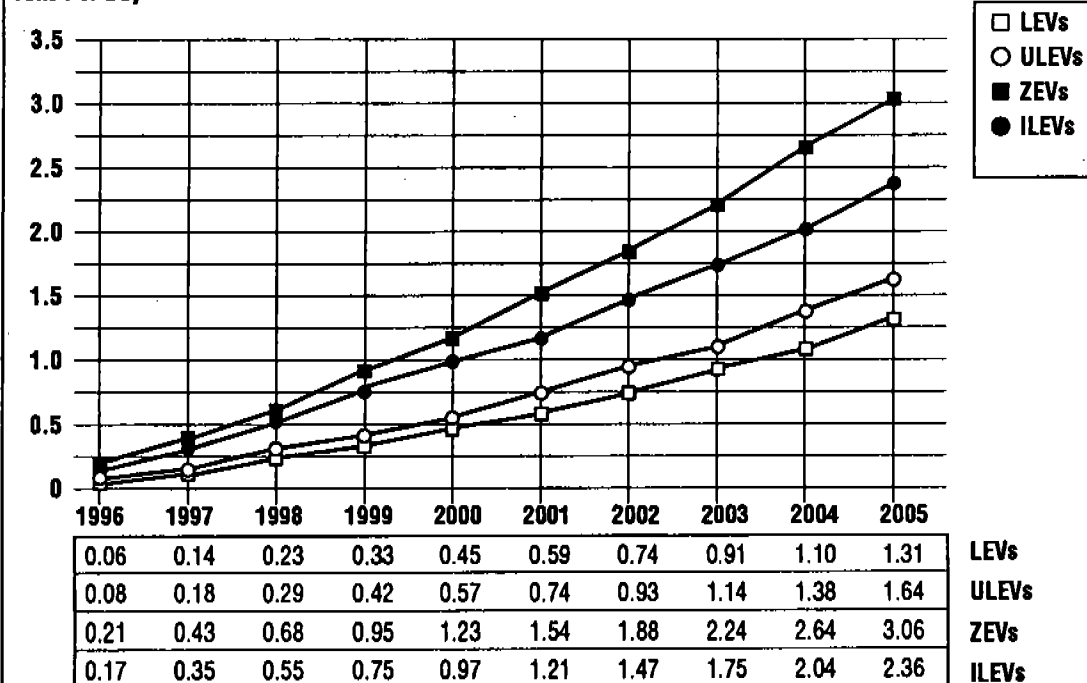


Figure 5

NO_x Benefits of CFFV Program with 10,000 Vehicles Per Year and "Appropriate" I/M

Tons Per Day

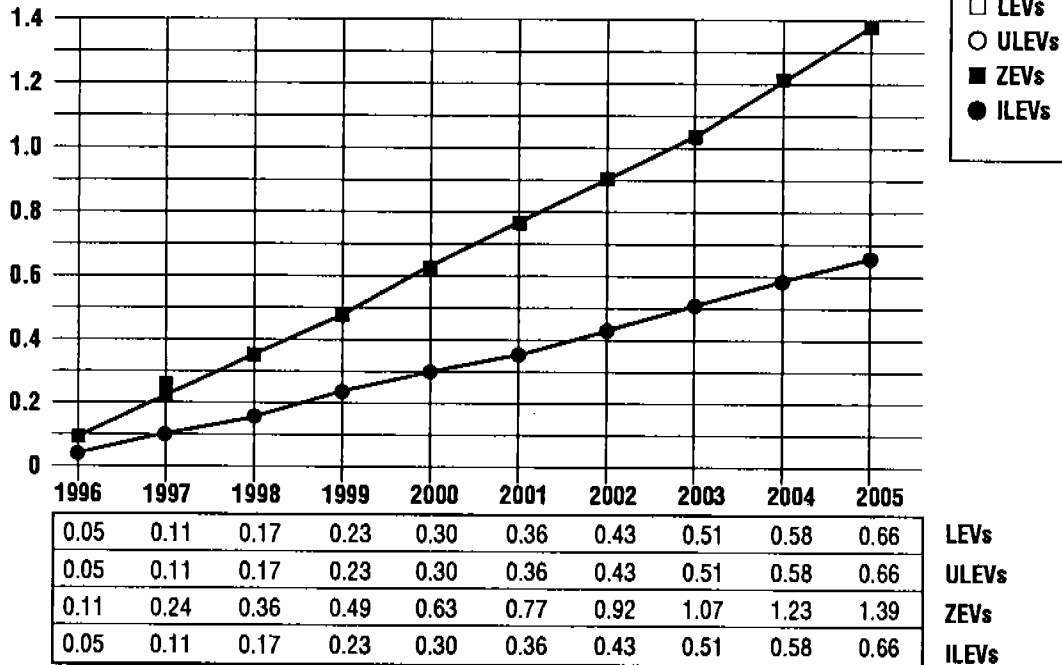


Figure 6

VOC Benefits of CFFV Program with 10,000 Vehicles and Enhanced I/M

Tons Per Day

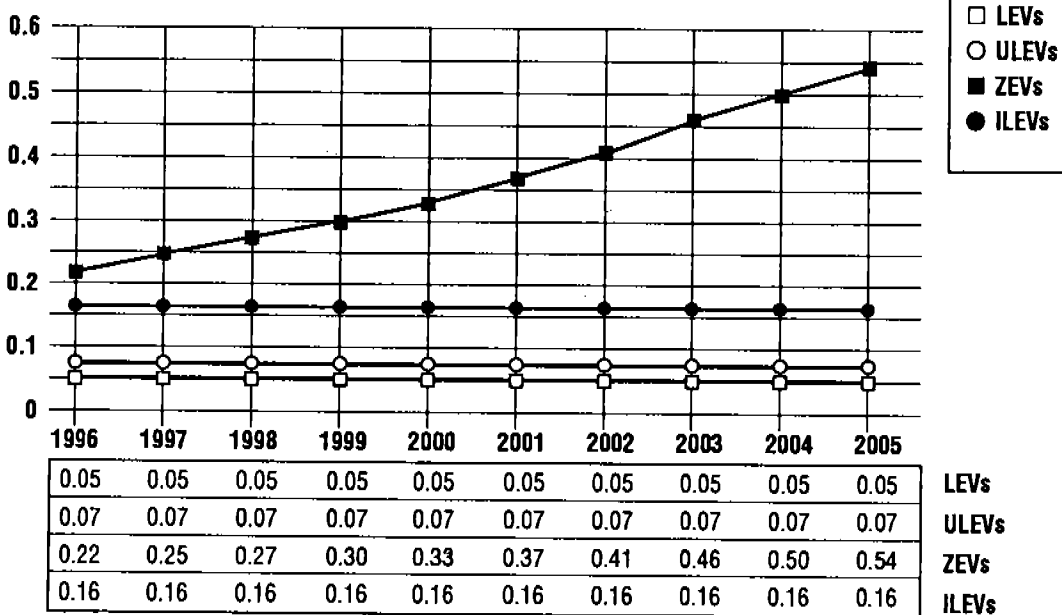


Figure 7

NO_x Benefits of CFFV Program with 10,000 Vehicles and Enhanced I/M Tons Per Day

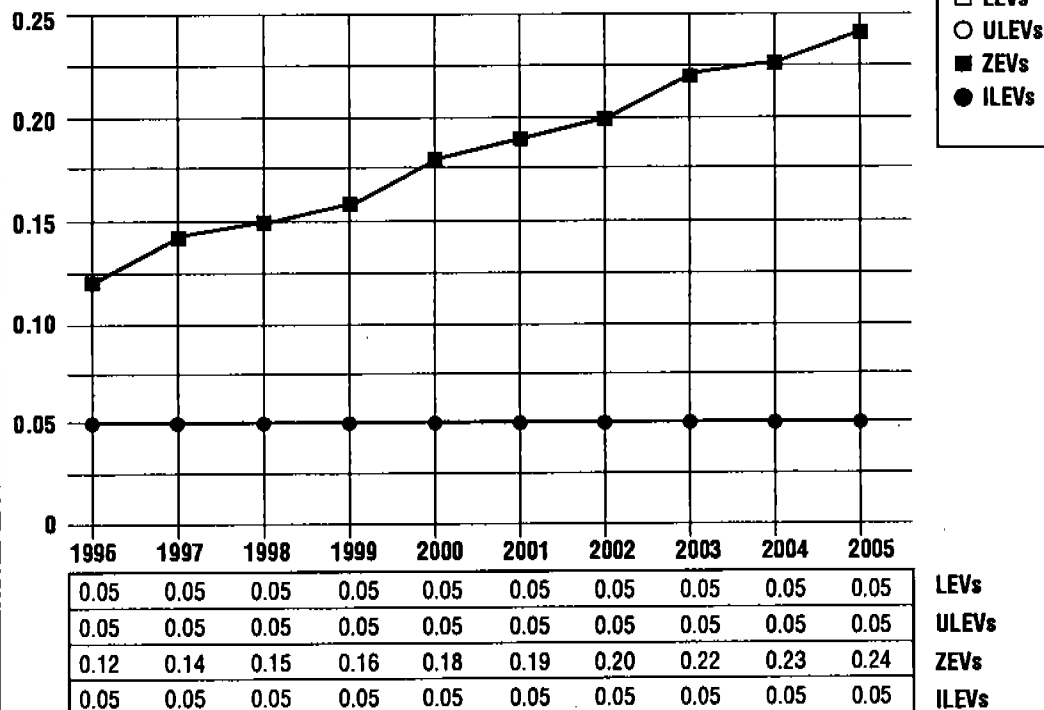


Figure 8

VOC Benefits of CFFV Program with 10,000 Vehicles Per Year and Enhanced I/M Tons Per Day

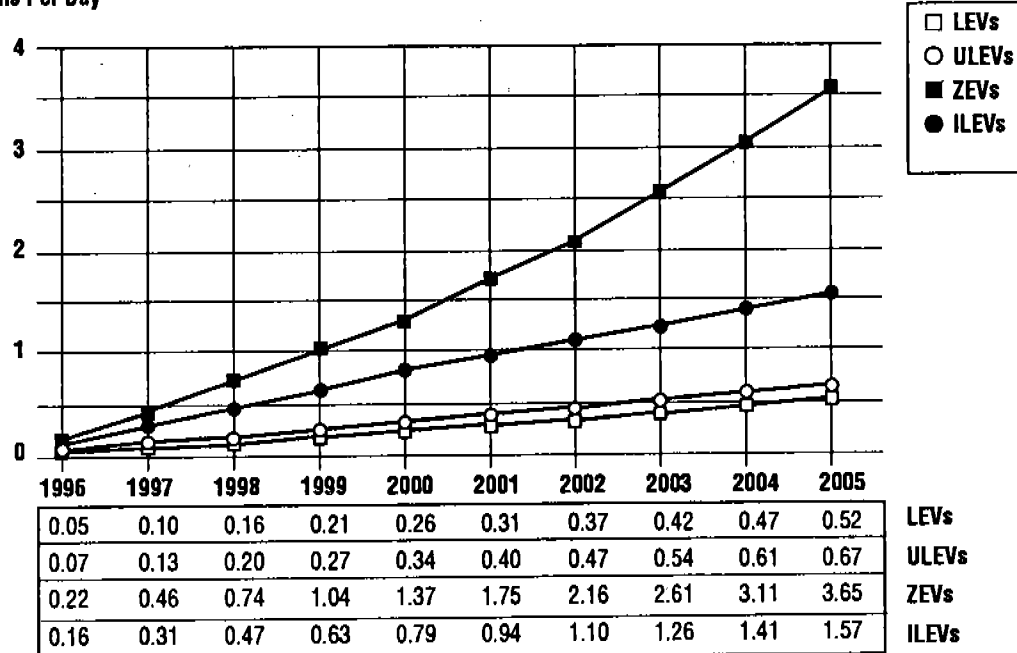
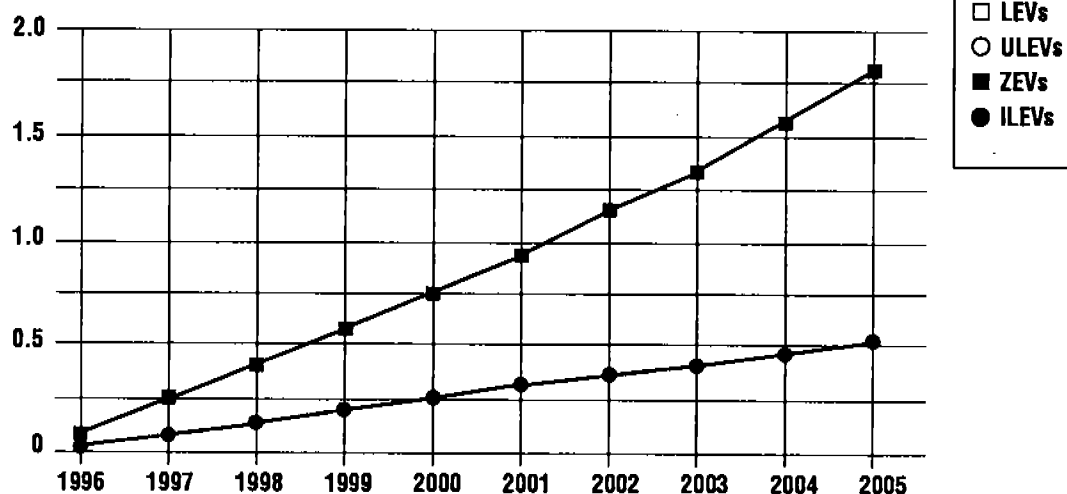


Figure 9

NO_x Benefits of CFFV Program with 10,000 Vehicles Per Year and Enhanced I/M

Tons Per Day



0.05	0.10	0.15	0.21	0.26	0.31	0.36	0.41	0.46	0.52	LEVs
0.05	0.10	0.15	0.21	0.26	0.31	0.36	0.41	0.46	0.52	ULEVs
0.12	0.26	0.41	0.57	0.75	0.94	1.14	1.35	1.58	1.82	ZEVs
0.05	0.10	0.15	0.21	0.26	0.31	0.36	0.41	0.46	0.52	ILEVs

Non-Road Vehicles and Engines

DESCRIPTION OF CONTROL MEASURE

The U.S. Environmental Protection Agency (EPA) estimates that on a typical summer day, nationally, non-road vehicles and engines are responsible for 36 percent of total motor vehicle and engine volatile organic compound (VOC) emissions (47 percent of the adjusted mobile source baseline) and 34 percent of nitrogen oxide (NO_x) emissions. It should be noted that the national non-road VOC emissions inventory includes a significant amount of emissions from recreational boating in areas that attain the National Ambient Air Quality Standard for ozone. As a result, the relative contribution of non-road sources to total VOCs is considerably higher than in most nonattainment areas. Within the broad category of non-road vehicles and engines, there is a wide variety of sources, as summarized in Table 1.

AVAILABLE CONTROL STRATEGIES

For the purposes of reducing VOCs from non-road vehicles and engines, controls for lawn and garden equipment and recreational marine engines appear especially promising. With respect to NO_x control, construction and agricultural equipment appear to hold the greatest potential.

Unfortunately, there are limited possibilities for controlling these emissions by 1996. Some reductions in emissions will occur, however, with the use of reformulated gasoline in non-road engines. EPA has recently released a guidance memorandum on the VOC emissions benefits of federal phase I reformulated gasoline that shows reductions in Class C areas of 3.3 percent in exhaust emissions and 3.5 percent in evaporative emissions, relative to the adjusted base year inventory. The memorandum explains that these reductions for non-road engines are smaller than the reductions associated with federal reformulated gasoline for highway vehicles due to differences in engine technology.

Another viable option is the replacement of two-stroke engines, either lawn mowers or marine engines, with four-stroke engines or, where possible, with electric engines. Further, in some cases, outright bans on certain types of engines could be imposed.

EPA has recently made preliminary estimates of the emissions rates of certain types of equipment; these emissions rates are summarized in Table 2.

In establishing credits for the replacement of any such equipment, it is important to pay special attention to

the following issues, as identified by the South Coast Air Quality Management District (SCAQMD):

- actual usage prior to scrapping;
- operability prior to scrapping;
- follow-up surveys to assure the continued use of cleaner substitutes;
- use of local activity data to establish actual emissions;
- disposal/scrapping mechanisms to assure permanent removal of equipment; and
- carefully conceived and implemented equipment-selection criteria.

With respect to marine engines, EPA has also noted that the potential for recreational boats to be trailered – in some cases for long distances to where they will actually be used – creates some special problems with ownership-based scrappage programs.

While it seems certain that some form of I/M program to improve the maintenance of non-road vehicles or engines would be beneficial, EPA has not yet issued guidance in this area.

COST EFFECTIVENESS

SCAQMD has developed the following estimates of the cost effectiveness of substituting electric lawn mowers for gasoline-fueled lawn mowers; estimates are expressed in terms of dollars per ton of VOC removed.

	Cordless	With Cords
2-stroke Engines	\$ 6,900	\$ 2,700
4-stroke Engines	\$28,000	\$11,000

FEDERAL RULEMAKING AND/OR GUIDANCE DOCUMENTS

In November 1991, EPA completed a *Non-road Engine and Vehicle Emissions Study Report* to evaluate the non-road source contribution to ozone and carbon monoxide nonattainment. In addition, the agency has also pursued the following related actions.

Class of Preempted Engines and Utility Engine Waiver: Under the Clean Air Act Amendments of 1990, EPA must define the class of non-road engines preempted from regulation by California. This fall, EPA expects to issue a final rule defining the preempted class of engines. The rule is expected to be based upon a compromise definition of the preempted class agreed to by the California Air Resources Board (CARB) and industry. Once the

STAPPA/ALAPCO *Recommendation*

► Since emissions from non-road engines have not been regulated in the past, there is little data available to assist state and local air pollution control agencies in assessing and developing successful and cost-effective strategies for reducing emissions from these sources in the near-term. Many strategies that have been used or considered to control emissions from other mobile sources, however, could be applicable to non-road equipment.

While the non-road category includes a broad array of engines and equipment, a small subset is responsible for the majority of emissions associated with these sources. Construction equipment represents, on average, approximately one-half of non-road NO_x emissions. The recently promulgated 50-horsepower and above non-road diesel standard will serve as the primary control strategy for non-road NO_x emissions. Lawn and garden equipment and recreational vessels emit about two-thirds of non-road-related VOC emissions in many areas. Efforts to reduce non-road VOC emissions, as part of the overall effort to meet mandated reductions, clearly should focus on these two categories.

Strategies that state and local air pollution control agencies may consider for achieving near-term reductions in VOC emissions from lawn and garden equipment and recreational vessels are listed on the next page. Beyond the effort of SCAQMD on lawn mower scrappage, little work has been conducted to date to quantify potential reductions from these optional strategies.

preemption definition is finalized, EPA plans to reopen the comment period on California's request to enforce its emissions standards for small utility engines.

Small Engine Standards: EPA and interested parties have tentatively agreed to a plan under which EPA will propose Phase I federal emissions standards for gasoline-powered engines at and under 25 horsepower (H.P.) based on the level of the California Phase I standards effective either January 1, 1996 or, possibly, January 1, 1997. EPA hopes to propose the Phase I standards by April 30, 1994. The Phase II standards will be developed as part of a formal negotiated rulemaking process that is anticipated to begin this fall.

Diesel Engine Standards: On May 17, 1993, EPA proposed its determination that non-road engines are a significant contributor to ozone nonattainment. This determination is required by the Clean Air Act before EPA may regulate non-road sources. EPA also proposed a smoke (opacity) standard and a 6.9 grams-per-brake-horsepower-hour NO_x standard for diesel-powered non-road engines, to take effect as follows:

50-99 H.P. (January 1998);
100-174 H.P. (January 1997);
175-750 H.P. (January 1996); and
751 H.P. and above (January 2000).

EPA believes current test procedures do not properly evaluate particulate emissions from non-road engines and is working with industry to evaluate alternative test procedures; Phase II standards may be proposed at a later date.

It is important to note that because these efforts focus primarily on new vehicles, very little if any emissions reduction can be expected prior to 1996.

STATE AND LOCAL CONTROL EFFORTS

SCAQMD has conducted extensive review of potential reductions in emissions from non-road vehicles and engines; of particular note is a SCAQMD issue paper on the lawn mower scrapping program.

CARB is currently developing proposed regulations for a variety of non-road engines and vehicles. The types of sources to be regulated include mobile pumps, generators, compressors, mobile refrigerator units, airport service equipment and forklifts. CARB is waiting to submit proposed rules until after EPA defines the class of engines that are preempted from regulation by California. CARB will likely consider standards in late 1993 or early 1994, depending upon how quickly EPA takes action on the preemption issue.

CARB is also developing proposed standards for non-road recreational vehicles, such as motorcycles and snowmobiles. CARB will likely consider at a public meeting later this year standards that could result in a phase out of two-cycle engines used on recreational equipment and will require zero-emission (i.e., electric) golf carts.

As with the federal efforts described above, these efforts focus primarily on new vehicles and hold little potential for emissions reductions prior to 1996.

Strategies State and Local Air Agencies May Consider for Achieving VOC Reductions from Lawn and Garden Equipment

Lawn and Garden Equipment

- Marketable Credits
 - scrapping of high-emission equipment
 - early introduction of low-emitting engines
- Emission-based "Feebate" Programs
- Bans
 - partial or total ban on sales of equipment employing certain high-polluting engines
- Evaporative Emission Controls Through Gasoline Tank Design Requirements
 - Stage II-compatible portable gasoline tanks
 - "design restrictions" to control spillage-related emissions
- Tune-up/Maintenance Programs
 - economic incentives to induce consumer participation in annual maintenance initiatives
 - required manufacturers' maintenance warranties

Recreational Vessels

- Marketable Credits
 - scrapping
- Emission-based Management
 - limits or bans on the use of 2-stroke engines
- "Feebate" Program for New Engines
- Emission-based Registration Fees
- Emission-based Launch Fees
- Stage II Vapor Recovery at Marinas
- Two-Cycle Oil Fees

REFERENCES

1. U.S. Environmental Protection Agency, Office of Mobile Sources. November 1991. *Non-road Engine and Vehicle Emission Study Report*.
2. U.S. Environmental Protection Agency, Office of Mobile Sources. August 23, 1993. "VOC Emissions Benefits for Nonroad Equipment with the Use of Federal Phase 1 Reformulated Gasoline." Memorandum from Phil Lorang to EPA Regional Offices.

Table 1.....

National Emissions Summary of Non-Road Vehicles and Engines (relative percentage contribution per summer day)

Equipment Category	VOC	NO _x
Lawn and Garden	20.8	0.5
Airport Service	0.3	2.8
Recreational	4.4	0.0
Recreational Marine	49.2	4.1
Light Commercial	3.1	0.8
Industrial	1.8	5.4
Construction	4.0	38.7
Agricultural	6.1	40.0
Logging	0.4	1.9
Marine Vessels	10.0	5.8

Table 2.....

Emission Rates of Non-Road Engines

Type of Equipment	Engine Type	HC (lbs/year)
Walk-Behind Lawnmowers:		
Consumer Use	4-stroke	7.18
Consumer Use	2-stroke	33.37
Professional Use	4-stroke	106.11
Professional Use	2-stroke	525.20
Trimmers/Edgers/Brushcutters:		
Consumer	2-stroke	6.15
Professional	2-stroke	90.12
Outboard Marine Engines:		
	2-stroke	244.00
	4-stroke	35.00

Transportation Control Measures

DESCRIPTION OF CONTROL MEASURE

Preliminary analyses indicate that most nonattainment areas will not be able to satisfy the requirements of the Clean Air Act Amendments of 1990 (CAAA) for a 15-percent reduction in volatile organic compound (VOC) emissions below the 1990 baseline by 1996 without achieving emissions reductions from in-use motor vehicles. Analyses of reductions expected to be achieved from other stationary and mobile source measures (e.g., RACT, reformulated fuels, enhanced motor vehicle Inspection and Maintenance, more stringent tailpipe standards, alternative fuels for fleets) suggest that for many areas, these measures alone are not adequate to achieve the CAAA's reasonable further progress (RFP) target for percentage reductions in emissions by 1996 and will provide no "excess" reductions to help satisfy RFP targets for post-1996 milestones. Reductions in emissions of VOCs and nitrogen oxides (NO_x) required to satisfy RFP targets for 1996 and beyond will depend heavily upon achieving reductions in in-use vehicle emissions.

In addition to complying with the RFP requirements of the CAAA, the importance of achieving reductions in in-

use vehicle emissions is also highlighted by separate CAAA provisions, including those in Section 182(d)(1), calling for the adoption of an interim State Implementation Plan (SIP) revision by 1992 to offset emissions increases expected to result from growth in vehicle miles traveled (VMT) and those requiring an interim conformity test, which calls upon transportation planning agencies to adopt plans that achieve an "annual emission reduction" of in-use vehicle emissions.

Both the CAAA and the Intermodal Surface Transportation Efficiency Act of 1991 specifically require that VMT growth be addressed in the surface transportation planning process. For ozone nonattainment areas designated as Serious, Severe and Extreme, states must verify every three years that current VMT is consistent with the VMT projections used in the SIP. When necessary, states must revise SIPs to achieve adjusted VMT/emissions reduction targets. Severe and Extreme nonattainment areas are required by the CAAA to adopt and enforce transportation control measures (TCMs) sufficient to offset emissions associated with VMT growth.

AVAILABLE CONTROL STRATEGIES

Table 1 summarizes the results of three efforts to identify TCMs that are currently in use and have demonstrated effectiveness in reducing travel demand (i.e., reducing the number of trips or trip lengths) or in contributing to mode shifts from the single-occupancy vehicle (SOV) to ride-sharing, public transit and other forms of shared-ride services, bicycles or walking. These documents include 1) the U.S. Environmental Protection Agency's *Transportation Control Measure Information Documents* (March 1992), which address the TCMs identified in Section 108(f) of the CAAA; 2) *Cost and Effectiveness of Transportation Control Measures: A Review and Analysis of the Literature* (April 1993), a draft report prepared by Apogee Research, Inc., for the National Association of Regional Council's (NARC's) Clean Air Project, the U.S. Environmental Protection Agency (EPA) and the U.S. Department of Transportation, that reviews the VMT-reduction potential of various strategies; and 3) *Motor Vehicle Use and the Clean Air Act: Boosting Efficiency by Reducing Travel* (July 1993), a review of the VMT-reduction potential of transportation strategies conducted by Michael Replogle of the Environmental Defense Fund (EDF).

Although EPA's TCM information documents, prepared to comply with a requirement of the CAAA, do not assess either the VMT impacts or the emissions-reduction potential of the measures addressed, the guidance does identify measures that EPA believes may be reasonably available. The documents are based upon a review of measures implemented in various communities around the world.

The Apogee/NARC assessment of TCMs considers VMT-reduction potential based upon a review of the literature and the application of planning judgment. While this document does not specifically identify the time period within which the estimated VMT reductions are expected to occur, it does recognize that the effectiveness of TCMs varies depending on circumstances.

The EDF analysis is the most comprehensive with regard both to the number of TCMs considered and the time period for implementation of listed measures. EDF also recognizes that the effectiveness of given TCMs varies depending on circumstances; however, unlike the others, EDF compares the effectiveness of TCMs over various time periods. For example, EDF identifies a number of TCMs that are considered not to be available by 1996, largely because of lead times needed for implementation, but which are identified as potentially effective strategies for 2000 and beyond.

Although the Apogee/NARC and EDF assessments of the VMT-reduction potential identified for each listed

TCM have not been independently reviewed for the purposes of this document, the conclusions of their respective reports are summarized here to provide an indication of the range of estimated reductions.

POTENTIAL NATIONAL EMISSIONS REDUCTION

It is important to note that it is not appropriate to quantitatively estimate the effectiveness of any particular TCM without considering the specific context in which the TCM will be implemented. As both Apogee/NARC and EDF acknowledge, the effectiveness of a TCM may vary significantly from one nonattainment area to another depending on circumstances that may vary significantly from area to area. A summary of the key variables that can substantially affect the effectiveness of any given TCM follows.

Existing Transportation System: The effectiveness of any given TCM or group of TCMs depends heavily upon the nature of the existing transportation system in a nonattainment area. For example, the addition of certain TCMs (such as land use policies designed to direct new development into corridors served by rail transit or enhanced bike/pedestrian access to transit) in an area heavily served by transit (e.g., New York City, where 40 percent of commuting trips are by transit) would have significantly different effects on VMT than the same measures adopted in an area without a well-developed transit system. Therefore, the characteristics of the transportation system to which a TCM is proposed to be added must be considered in evaluating the effectiveness of the measure.

Synergistic Effects of TCMs: TCMs taken in isolation tend to have minimal benefits compared to integrating numerous, related TCMs. For example, pricing strategies are designed to increase the cost of driving alone compared to the cost of alternative modes. Therefore, if only one pricing measure is adopted, such as congestion pricing on major regional highways, the benefits may be minimal because the public response may be to choose unpriced alternate routes, as opposed to abandoning their SOVs. However, if regional parking pricing is added to congestion pricing, the incentive to leave the personal auto at home and use an alternative mode is enhanced.

Even greater benefits are achieved if the revenues generated by pricing measures are used to increase the supply of alternative modes (e.g., adding bus routes to provide more convenient service in more areas, reducing waiting times by adding more service to existing routes or adding dial-a-ride door-to-door service to the existing system), in which case the convenience and speed of alternative modes can be improved as the cost of the SOV is increased. Whereas, if transit service were enhanced without changing

STAPPA/ALAPCO *Recommendation*

► Areas should evaluate the potential effectiveness of TCMs given their particular needs and circumstances, with a special emphasis on pricing strategies, which offer the greatest potential for emission reductions.

the relative price of driving an SOV compared to the transit alternatives, little increased ridership would be expected. Both the mobility and air quality benefits of such an integrated approach is far greater than the benefits of implementing only one such measure.

Since success of TCM strategies depends upon the setting in which they are applied, the most effective TCM strategy will combine TCM disincentives, including programs to cash out parking subsidies, Employee Commute Options and congestion pricing, with TCM incentives, such as ridesharing services, HOV lanes, intermodal transfers and connections and park-and-ride facilities. Such combinations of measures will be more successful at promoting changes in mode choice, by providing drivers with options for substituting a less polluting mode for their SOV trip.

In recognition of the synergistic effect of multiple strategies, the lists of TCMs presented in Tables 1 and 2 groups TCMs into sets of strategies that are closely related in concept and that are likely to be more effective if considered as a package.

Comprehensiveness of a Strategy: TCMs applied only to limited parts of a nonattainment area or only to certain corridors will be less effective than measures applied throughout a nonattainment area. For example, a pricing strategy applied only to parking in a central business district will have a significantly lower impact on regional emissions than a regional parking strategy. Similarly, adding a high-occupancy vehicle (HOV) lane to one limited-access corridor in a nonattainment area will have an impact on those who drive that corridor, but will have a much more limited impact than if an HOV network is built to connect all the limited access links in the regional highway system.

Land use policies that encourage higher-density development in transit corridors in one part of the nonattainment area can have an effect on mode split in that corridor, but the regional emissions reduction benefits are much greater if similar policies are applied to all transit corridors in a metropolitan area.

In view of these and other variables, it is not possible to predict in advance the quantitative benefits that may result from the adoption of any given mix of the listed TCMs in a specific nonattainment area. However, the estimated reductions in VMT identified in Tables 1 and 2 are useful for comparing the relative effectiveness of TCMs in any area. They are also useful for the purposes of making first-order estimates of the kinds of measures that may be necessary to achieve the magnitude of emissions reduction required from mobile source emissions in order to achieve RFP milestones and/or attain the NAAQS.

Once policy-makers for a given area have selected specific TCMs for modeling analysis in order to demonstrate the emissions reductions required for a SIP revision, it is important to recognize that some transportation models traditionally used to assess the need for expanded highway capacity are not designed for or capable of quantitatively assessing the VMT-reduction effects of some of the strategies listed here. Traditional models do not have algorithms capable of assessing the effects of price on driver behavior and are especially ill-suited to test the different impacts on travel demand and mode split likely to be achieved by implementing alternative pricing strategies. Models can assess the differences in travel demand likely to result from two alternative regional-scale land-use scenarios, but are less well-suited to evaluating the benefits of regional policies that affect land use iteratively, such as policies that increase bike/pedestrian access to transit or that promote neighborhood retail as a strategy to reduce travel demand.

As a result, planners may find that a given mix of TCMs may appear potentially attractive as a regional package of options, but when tested using traditional transportation models, show little or no benefits compared to those claimed for the measures in Tables 1 and 2. This result may be an artifact of a model that was never designed to assess these kinds of measures on travel demand or mode split.

There is little value in engaging in a SIP-planning process with an outdated transportation model as the only tool for evaluating the emissions reduction benefits of alternatives under consideration. It is, therefore, important to protect the political and financial investment in the planning process by upgrading the regional transportation model to give decision-makers a tool that will have the sensitivity needed to provide useful and reliable information.

Without such a tool to test the choices resulting from the planning process, the resulting SIP could prove far more costly than it need be or far less effective than it could be.

To address this concern, STAPPA and ALAPCO have adopted performance guidelines for regional transportation models as part of the *STAPPA/ALAPCO Alternative Proposed Federal Transportation Conformity Regulation*, adopted on March 3, 1993. State and local agencies are encouraged to upgrade the regional transportation model to meet these performance criteria before completing the quantitative modeling analysis of proposed TCMs for the SIP.

FEDERAL RULEMAKING AND/OR GUIDANCE DOCUMENTS

In March 1992, EPA published *Transportation Control Measure Information Documents*, which address the TCMs identified in Section 108 of the CAAA.

REFERENCES

1. U.S. Environmental Protection Agency, Office of Mobile Sources. March 1992. *Transportation Control Measure Information Documents*.
2. U.S. Environmental Protection Agency. March 1992. *General Preamble Title I Clean Air Act Amendments 1990*.
3. U.S. Environmental Protection Agency, Office of Mobile Sources. Spring 1992. *Transportation Control Measures: State Implementation Plan Guidance*. Revised Guidance.
4. U.S. Environmental Protection Agency, Office of Policy, Planning and Evaluation, Jon Kessler and William Schroeder. January 1993. *Meeting Mobility and Air Quality Goals: Strategies That Work*.
5. Apogee Research, Inc. April 1993. *Cost and Effectiveness of Transportation Control Measures: A Review and Analysis of the Literature*. Draft Report Prepared for the National Association of Regional Councils, the U.S. Environmental Protection Agency and the U.S. Department of Transportation (final report expected Fall 1993).
6. Environmental Defense Fund, Michael Replogle. July 1993. *Motor Vehicle Use and the Clean Air Act: Boosting Efficiency by Reducing Travel*. Draft.

Table 1

Estimates of VMT-Reduction Potential of TCMs in U.S. Urbanized Areas

Potential Aggregate VMT Reduction Growth Trends	Category in 1992 EPA TCM Info Documents ^a	Apogee/NARC Estimated VMT Reduction ^b		EDF Estimated VMT Reduction For All Daily Travel ^c		
		Max In Lit.	Potential	1996	2000	2010
A. Pricing Measures		14.5	12.6	4.5	9.0	18.7
Cash Out Employer-Paid Parking & Boost Parking Fees	# 2,8	4.0	3.0	1.6	2.3	4.2
Parking Pricing for Non-Work-Related Destinations	# 8	4.2	4.2	0.7	2.1	3.8
Pay-As-You Drive Auto Insurance (\$.50/gal)	—	—	—	1.0	1.9	2.5
Smog/VMT Tax	—	0.6	0.4	0.1	0.2	0.5
IVHS Automated Toll Express Lanes/Congestion Pricing	—	5.7	5.0	0.0	0.9	4.7
Central Area Pricing	—	—	—	0.0	0.1	0.3
Transit Fare Integration, Marketing, Pass Subsidy	#5	—	—	1.0	1.5	2.9
B. New Options for Short Trips		0.0	0.0	0.9	3.2	8.0
Traffic Calming, Bicycle/Pedestrian Improvements	#10	0.0	0.0	0.9	2.7	5.4
Develop Traffic Cells in Selected Primary Centers	#12	—	—	0.0	0.5	2.6
C. Smart Systems & New Technologies		3.4	1.1	0.5	2.7	6.6
IVHS Advanced Transit Information Systems	#5	—	—	0.4	1.1	2.9
Smart Communities: Teleshopping & Telelogistics	—	—	—	0.1	1.5	3.6
Telecommuting	#3	3.4	1.1	0.0	0.1	0.1
D. Growth Management and Land Use Policies		5.4	5.4	0.4	2.7	9.5
Encourage Accessory Apartments, Neighborhood Retail	#14	—	—	0.3	2.0	5.0
Growth Management Favoring Infill/Clustering/Centers	#14	5.4	5.4	0.1	0.7	4.5
E. Improved Public Transportation		2.6	1.0	1.5	3.4	7.3
Expanded Paratransit Services	#5	—	—	0.6	1.2	2.5
New Rail Starts & Major Transit Investment/Improvements	#5	2.6	1.0	0.4	1.1	2.6
Enhanced Bicycle/Pedestrian Access to Transit	#5,10	—	—	0.5	1.0	2.1
F. Marketing and Incentives		5.9	2.2	1.3	2.7	3.6
Employer Trip Reduction Programs	#1,2	3.3	1.0	0.5	1.0	1.0
Compressed Work Week	#3	0.6	0.8	0.1	0.3	0.2
Public Education Campaigns for New Transportation Ethics	—	—	—	0.5	1.0	2.0
Area Wide Ridesharing Programs	#4	2.0	0.4	0.1	0.4	0.4
G. Automobile Infrastructure		1.8	1.8	-0.1	-0.8	-2.0
HOV Lanes	#6	1.4	1.4	0.1	0.4	0.7
Park-and-Ride Lots	#9	0.5	0.5	0.1	0.3	0.5
Traffic Signal Timing/Intersection Traffic Flow Enhancement	#7	-0.0	-0.0	-0.3	-0.9	-2.0
Traffic Incident Management	#7	-0.1	-0.1	-0.1	-0.6	-1.2
H. Miscellaneous: Temporary & Non-VMT Related		—	—	—	—	—
Special Events Management	#11	—	—	—	—	—
Accelerated Retirement of Vehicles	#13	—	—	—	—	—
Controls on Extended Vehicle Idling	#15	—	—	—	—	—
Controls on Low-Temperature Cold Starts	#16	—	—	—	—	—
Total Reduction from Growth Trend		33.6	24.0	8.9	22.9	51.7
Growth Trend: Ratio to 1990				1.1	41.23	1.42
With Comp. Demand Management: Ratio to 1990				1.05	1.00	0.90

^aCambridge Systematics, Inc. for the U.S. Environmental Protection Agency, Office of Mobile Sources. Transportation Control Measure Information Documents. March 1992.

^bApogee Research, Inc. for the National Association of Regional Councils, the U.S. Environmental Protection Agency and the U.S. Department of Transportation. Costs and Effectiveness of Transportation Control Measures (TCMs): A Review and Analysis of the Literature (draft study). April 1993. Preliminary data subject to changes.

^cEnvironmental Defense Fund estimates based on literature review and analyses by Michael Replogle, EDF. July 1993. (For additional information on assumptions and sources, see Transportation Conformity and Demand Management: Vital Strategies For Clean Air Attainment by Michael Replogle, EDF; April 30, 1993.)

TRANSPORTATION CONTROL MEASURES

Table 2.....
Average Estimated Potential of Comprehensive Transportation Demand Management in U.S. Urbanized Areas, By Trip Purpose^a

I. Potential Aggregate VMT Reduction from Growth Trends by Trip Purpose	Estimated VMT Reduction (%) Daily Travel			Estimated VMT Reduction (%) Work Travel			Estimated VMT Reduction (%) Non-Work Travel		
	1996	2000	2010	1996	2000	2010	1996	2000	2010
A. Pricing Measures	4.5	9.0	18.7	7.3	15.5	31.5	3.4	6.7	15.0
Cash Out Employer Paid Parking & Boost Parking Fees	1.6	2.3	4.2	5.0	7.5	11.0	0.3	0.5	2.0
Parking Pricing for Non-Work-Related Destinations	0.7	2.1	3.8	0.0	0.8	1.5	1.0	2.5	4.5
Pay-As-You Drive Auto Insurance (\$.50/gal)	1.0	1.9	2.5	1.0	3.0	4.0	1.0	1.5	2.0
Smog/VMT Tax	0.1	0.2	0.5	0.1	0.2	0.5	0.1	0.2	0.5
IVHS Automated Toll Express Lanes/Congestion Pricing	0.0	0.9	4.7	0.1	2.0	10.0	0.0	0.5	3.0
Central Area Pricing	0.0	0.1	0.3	0.1	0.5	2.0	0.0	0.0	0.0
Transit Fare Integration, Marketing, Pass Subsidy	1.0	1.5	2.9	1.0	1.5	2.5	1.0	1.5	3.0
B. New Options for Short Trips	0.9	3.2	8.0	0.5	2.5	6.5	1.0	3.5	8.5
Traffic Calming, Bicycle/Pedestrian Improvements	0.9	2.7	5.4	0.5	2.0	3.5	1.0	3.0	6.0
Develop Traffic Cells in Selected Primary Centers	0.0	0.5	2.6	0.0	0.5	3.0	0.0	0.5	2.5
C. Smart Systems & New Technologies	0.5	2.7	6.6	1.2	3.0	6.0	0.3	2.6	6.8
IVHS Advanced Transit Information Systems	0.4	1.1	2.9	0.5	1.5	2.5	0.3	1.0	3.0
Smart Communities: Teleshopping & Telelogistics	0.1	1.5	3.6	0.0	0.0	0.0	0.2	2.0	4.8
Telecommuting	0.0	0.1	0.1	0.7	1.5	3.5	-0.2	-0.4	-1.0
D. Growth Management and Land Use Policies	0.4	2.7	9.5	0.4	2.5	8.0	0.4	2.8	10.0
Encourage Accessory Apartments, Neighborhood Retail	0.3	2.0	5.0	0.3	2.0	5.0	0.3	2.0	5.0
Growth Management Favoring Infill/Clustering/Centers	0.1	0.7	4.5	0.1	0.5	3.0	0.1	0.8	5.0
E. Improved Public Transportation	1.5	3.4	7.3	1.1	3.0	6.5	1.6	3.5	7.5
Expanded Paratransit Services	0.6	1.2	2.5	0.2	0.5	1.0	0.7	1.5	3.0
New Rail Starts & Major Transit Investment/Improvements	0.4	1.1	2.6	0.4	1.5	3.0	0.4	1.0	2.5
Enhanced Bicycle/pedestrian Access to Transit	0.5	1.0	2.1	0.5	1.0	2.5	0.5	1.0	2.0
F. Marketing and Incentives	1.3	2.7	3.6	3.0	6.0	7.0	0.5	1.0	2.0
Employer Trip Reduction programs	0.5	1.0	1.0	2.0	4.0	4.0	0.0	0.0	0.0
Compressed Work Week	0.1	0.3	0.2	0.5	1.0	1.0	0.0	0.0	0.0
Public Education Campaigns for New Transportation Ethics	0.5	1.0	2.0	0.5	1.0	2.0	0.5	1.0	2.0
Area Wide Ridesharing Programs	0.1	0.4	0.4	0.5	1.5	1.5	0.0	0.0	0.0
G. Automobile Infrastructure Systems	-0.1	-0.8	-2.0	0.0	0.5	1.0	-0.2	-1.3	-3.0
HOV lanes	0.1	0.4	0.7	0.5	1.5	3.0	0.0	0.0	0.0
Park-and-Ride Lots	0.1	0.3	0.5	0.5	1.0	2.0	0.0	0.0	0.0
Traffic Signal Timing	-0.3	-0.9	-2.0	-0.5	-1.0	-2.0	-0.2	-0.8	-2.0
Traffic Incident Management	-0.1	-0.6	-1.2	-0.5	-1.0	-2.0	0.0	-0.5	-1.0
Total Reduction from Growth Trend	8.9	22.9	51.7	13.5	32.5	65.5	7.2	20.1	49.8
Growth Trend: Ratio to 1990	1.14	1.23	1.42	1.14	1.23	1.42	1.14	1.23	1.42
With Comp. Demand Management: Ratio to 1990	1.05	1.00	0.90	1.00	0.91	0.77	1.07	1.03	0.92
II. Assumed Composition of Travel by Purpose	1990	1996	2000	2010					
% of VMT for Work Travel	28	27	26	24					
% of VMT for Non-Work Travel	72	73	74	76					

^aEstimates based on literature review and analyses by Michael Replogle, Environmental Defense Fund, July 1993. For additional information on assumptions and sources, see Transportation Conformity and Demand Management: Vital Strategies For Clean Air Attainment by Michael Replogle, EDF, April 30, 1993.

Employee Commute Options

DESCRIPTION OF CONTROL MEASURE

Section 182(d)(1)(B) of the Clean Air Act Amendments of 1990 (CAAA) requires employers with more than 100 employees located in Severe or Extreme ozone nonattainment areas to increase the average passenger occupancy per employee vehicle to a level 25 percent above the average vehicle occupancy for the nonattainment area as a whole. In order to comply with the Employee Commute Options (ECO) program requirement, each state with a Severe or Extreme ozone nonattainment area must establish a process of plan submission, approval, periodic reporting on target achievements and plan revision to achieve the applicable target. Employers are required to develop compliance plans with strategies to reduce work-related vehicle trips and vehicle miles traveled (VMT) during peak traffic periods.

Pursuant to the provisions of the CAAA, the following areas are required to implement an ECO program:

Los Angeles, CA
San Diego, CA
Southeast Desert Modified Air Quality
Management Area (San Bernadino, CA)

Ventura County, CA
Chicago, IL
Baltimore, MD
NY/NJ/CT Metropolitan Area
Philadelphia, PA/Wilmington, DE/Trenton, NJ
Houston/Galveston/Brazoria, TX
Milwaukee, WI

AVAILABLE CONTROL STRATEGIES

The U.S. Environmental Protection Agency (EPA) has issued ECO guidance that identifies the following measures as examples of steps that employers may take to meet the program requirements: 1) provide direct financial incentives to promote commute modes other than driving alone; 2) sponsor or subsidize car/van pools; 3) subsidize use of public transit; 4) institute compressed work weeks and/or flexible work hours; 5) offer telecommuting and work-at-home options; 6) provide comprehensive rideshare matching services; 7) subsidize mid-day shuttles to local shopping areas; 8) provide company-owned fleet vehicles for ridesharing; 9) charge those who drive alone for parking; 10) offer preferential or subsidized parking for car/van

pools; 11) provide a guaranteed ride home program; and 12) improve facilities to promote bicycle use.

POTENTIAL NATIONAL EMISSIONS REDUCTION

EPA estimates that the ECO program can result in a 1- to 2-percent reduction in VMT. Actual benefits will depend upon the percent of total VMT derived from work trips; the percent of employees working for large companies subject to the program; the percent of work trips that occur during peak hours; the degree of employer compliance in preparing and implementing an incentive plan; and the effectiveness of the incentives offered by employers. These variables will be specific to each nonattainment area.

FEDERAL RULEMAKING AND/OR GUIDANCE DOCUMENTS

EPA issued final guidance on the ECO program in March 1993.

STATE AND LOCAL CONTROL EFFORTS

Although all areas required by the CAAA to implement an ECO program are engaged in efforts to comply with the statutory requirements, at least two local rules addressing the reduction of employee trips are worthy of review – the Ventura County Air Pollution Control District's Rule 210 and the South Coast Air Quality Management District's Regulation XV.

STAPPA/ALAPCO Recommendation

► For areas not already required by the CAAA to adopt an ECO program, implementation of an ECO program may offer some additional reductions.

REFERENCES

1. U.S. Environmental Protection Agency, Office of Mobile Sources. March 1993. *Final Guidance on Employee Commute Options Program*.

Accelerated Vehicle Retirement

DESCRIPTION OF CONTROL MEASURE

Old automobiles with no or few emissions controls are typically a source of high emissions. While normal attrition of the fleet alleviates a portion of these emissions, some high-emitting vehicles remain in operation and contribute to emissions problems for long periods of time. It is these vehicles that accelerated vehicle retirement – also known as scrappage programs – seek to remove from the fleet by providing an incentive for owners to retire these vehicles sooner than they would have in the absence of a program.

A state or local government can design a scrappage program as a State Implementation Plan (SIP) measure or, in conjunction with a private company, as a program to generate emissions credits to satisfy existing or new source-specific requirements.

In order to ensure that scrappage programs yield the expected levels of emissions reductions, minimum safeguards should be provided in order to receive credit. If the following program design elements are not present, EPA will consider the program particulars on a case-by-case basis, due to greater uncertainty of emissions reduction claims.

Vehicle Must Meet Twelve-Month Registration

Requirement: To ensure that vehicles are not imported into the area for the sole purpose of being sold in the program, eligible vehicles must have been registered by the owner at an address within the nonattainment area continuously for at least the previous twelve months prior to the date the vehicle is purchased by the program.

Vehicle Must be Operable and Driven to Site:

Scrappage programs should seek to remove those high-emitting vehicles that would have been operated in future years and not to attract vehicles that are inoperable or have little remaining useful life. Eligible vehicles are required to be operable and driven to the intake site to increase the probability that the scrappage program will attract in-use vehicles. In addition, they must undergo a physical inspection designed to assure that major body components have not been removed and that the vehicle could be readily used for normal transportation purposes.

Owner Must be Present and Possess Valid Title:

The owner of the vehicle or his or her legal representative or, in the case of corporate-owned vehicles, a certified agent, must be present to ensure proper passage of title and to verify the owner's intention to retire the vehicle. Since these vehicles will be either destroyed or dismantled for partial recycling, they cannot be returned to the owner if a

mistake is made. The identification of the person delivering the vehicle, the Vehicle Identification Number and the validity of the vehicle title must be verified.

Owner Must Have a Valid I/M Certificate: As a further assurance that the vehicle being retired is an in-use vehicle, where motor vehicle Inspection and Maintenance (I/M) programs are in effect, scrappage programs must require vehicle owners to present the I/M certificate (or waiver certificate, if the car received a waiver) obtained from the most recent testing period.

Vehicles Must be Disposed of in an Environmentally Safe Manner: A scrappage program will generate solid, liquid and gaseous waste that must be disposed of or recycled in an environmentally sound manner. EPA requires that all retired vehicles be scrapped by facilities that are licensed and approved to dispose of all the types of waste created by the scrappage of vehicles or recycling of vehicle parts, where licensing requirements apply. In areas where such licensing requirements are not in place, programs must adhere to all applicable federal, state and local recordkeeping procedures and laws for disposal of vehicles. Where legal requirements are not in effect, all prudent environmental safeguards should be strictly followed to ensure that scrappage of vehicles does not result in environmental degradation.

Sponsors Must Provide Emissions Estimates Based Upon Certain Criteria: The most recent version of EPA's MOBILE model must be used for program evaluations begun three months or more after the release of an updated model. As an alternative to the MOBILE model's average emissions approach, program sponsors may choose to use actual tested emissions levels as the basis for emissions estimates. For the purpose of quantifying those emissions levels, a transient mass exhaust emissions test and, if desired, an evaporative emissions test procedure should be used. If this approach is used, other program design elements will be required to guard against the possibility of tampering to increase emissions and the resulting credits.

Sponsors of Programs Over 2,500 Vehicles are Subject to Minimum Data Gathering Requirements: Sponsors retiring more than 2,500 vehicles within any twelve-month period are subject to a minimum data gathering requirement. Sponsors must collect emissions data, using EPA's IM240 mass emission test and evaporative purge and pressure tests, from a random sample of a statistically significant number of participating vehicles. Sponsors must also collect information on annual vehicle miles traveled (VMT), expected remaining useful life and model year of replacement vehicle. The information will be provided to EPA for evaluation of program emissions estimates and for the purpose of improving future guidance on emissions reduction estimates for scrappage programs.

AVAILABLE CONTROL STRATEGIES

While the potential for variations exist, scrappage programs will basically work in the following way. A state or local government or company would advertise for the purchase of certain vehicles. Owners would then voluntarily sell their vehicles to the sponsor of the program and the vehicles would be removed from the fleet. The sponsor would receive an emissions credit for each car removed from operation equivalent to the difference between the emissions from the retired vehicle and the emissions from the replacement vehicle. EPA encourages the consideration of programs that include trucks.

Basic scrappage programs can be varied by changing the focus of vehicle selection from general model-year eligibility to emissions-level eligibility. EPA encourages scrappage programs to focus on high emitters and recognizes that there are many possible program variations that could assist in that regard. Some may require alternative assumptions or other modifications to the basic methodology for the calculation of emissions reductions.

EDF/GM Test and Pool Approach: A scrappage program proposal designed by the Environmental Defense Fund (EDF) and General Motors Corporation (GM) addresses some of the inherent areas of uncertainty and is conducive to establishment of an ongoing program. The EDF/GM design targets high-emitting vehicles regardless of age, awards emissions reduction credits on the basis of emissions testing for each scrapped vehicle and creates an emissions reduction "pool" for the purpose of nullifying the incentive to tamper with individual vehicles.

Under the program, vehicles are purchased for a negotiated amount reflecting the local market price for emissions reduction credits in the area and generic information about the emissions and expected remaining life of the specific vehicle model and vintage. Presumably, in an active, ongoing program, private parties would accumulate and circulate such information, just as the retail market for used cars has created a "Blue Book," recording generic information about the transportation value of vehicles. Following purchase, the buyer would present the vehicle to an independent testing center where the emissions would be measured. The emissions results, factored by projected annual VMT and remaining life, would be included in pools of emissions results from all cars purchased by scrappage sponsors in the area. Emissions values would be reduced to reflect the emissions from replacement vehicles. Such pools would be created for each year of expected remaining life.

As an added assurance that the program provides net emissions reductions, each year's emissions pool would be discounted by 10 percent. The remainder of the annual-

ized emissions pool would be distributed in the form of transferable (mobile emission reduction credits) MERCs, to each scrappage sponsor on a pro-rata basis reflecting the sponsor's share of all scrapped vehicles whose emissions were included in the pool.

To bolster the pooling approach for minimizing the incentive for sponsors to tamper with vehicles to increase their emissions, local regulatory authorities would adopt an oversight procedure. By selling a "control" vehicle with known emissions to a scrappage sponsor and obtaining the emissions test results from the independent test facility, tampering could be detected. Stiff penalties for tampering, including disqualifying the sponsor from future scrappage programs and disallowing MERCs already generated by the sponsor would nullify the incentive to tamper, while also ensuring that any tampering already committed would not have an adverse effect on air quality.

Scrappage and Remote Sensing: Programs that use a remote sensing device (RSD) to target vehicles for participation in a scrappage program may reduce some of the uncertainty found in programs with eligibility based only on age and improve cost effectiveness. Specifically, use of an RSD may increase program cost effectiveness by identifying older cars that are higher emitters than the average car of their age and reduce credit overestimation by identifying vehicles that are actually in active service and not just being stored or infrequently used. Scrapping only vehicles identified by on-road remote sensing should, therefore, produce more emissions reductions per scrapped vehicle. EPA encourages consideration of this approach. However, if the emissions estimates used for calculating the MERCs are to be increased over those predicted by the MOBILE model, transient mass emissions testing is required to determine how much larger the increases should be. Special program design elements should also be included to guard against intentional tampering for the purpose of increasing emissions and the resulting credits. An EDF/GM-type measuring approach is one solution.

Scrappage and I/M Programs: Adding a vehicle scrappage option to a motor vehicle Inspection and Maintenance (I/M) program is another way to improve program benefits and/or reduce costs. I/M programs require vehicles to pass an emissions test in order to be registered or licensed for operation. If a vehicle does not pass the test, owners are required to make repairs up to a certain dollar amount. If, after making the repairs, the vehicle still cannot pass the test, the owner may receive a waiver allowing the vehicle to be licensed for use until the next scheduled test.

By incorporating a scrappage component into the I/M program, vehicles that fail an I/M test, and which have not yet been successfully repaired or are known to need

repairs costing more than a predetermined amount, would become eligible for scrappage. Depending upon the estimated cost of repair, emissions reduction credits would be based upon either the vehicle's emissions levels from an IM240 test or emissions estimates from the MOBILE model.

For example, vehicles requiring less than \$300 in repairs would be assigned the MOBILE estimate of emissions levels for the appropriate model year. Vehicles requiring \$300-\$450 in repairs would be assigned an emissions level that is less than the initial IM240 test results, to reflect the repairs and the post-repair emissions levels likely to be reached in absence of the scrappage option. This post-repair emissions level is derived from the TECH5 relationship between initial test emissions levels and post-repair test emissions levels. Vehicles requiring in excess of \$450 in repairs would be assigned emissions levels based upon their initial I/M transient test. It should be noted that serviceability and repair costs are difficult to predict without professional diagnosis. Furthermore, a conflict of interest could occur if the diagnosis were performed by someone whose judgment may be influenced by the sponsor of the scrappage program. Therefore, it is reasonable to require proof of an independent professional diagnosis that supports the cost estimate.

Scrappage program designs that incorporate an I/M element in this way will not only have greater assurance that they are retiring high-emitting vehicles, but could possibly result in lower purchase costs for the sponsors, as well as an increased incentive to scrap for the vehicle owner, who will likely be faced with immediate repair costs if the vehicle is not scrapped. EPA encourages this approach as a way to increase the assurance of environmental benefits and as an environmentally sound option to issuing a waiver to a high-emitting vehicle. As with the EDF/GM approach and the remote sensing approach described above, special program features to guard against cheating or fraud would be required.

POTENTIAL NATIONAL EMISSIONS REDUCTION

EPA has developed an example to illustrate the methodology for determining emissions reductions. The hypothetical example is based upon data representing national fleet averages and may not be representative of any particular urban area. Table 1 provides an estimate of the emissions reductions that could be realized from a program operating in 1993, in which 10,000 pre-1980 model vehicles are retired.

All of the emissions estimates were made using MOBILE4.1. Baseline and post-program scenarios use national average default values to describe the vehicle fleet,

standard speeds and typical summer temperatures. The scenarios assume a low-altitude area with an American Society for Testing and Materials (ASTM) Class C fuel. The area is also assumed to have an existing basic I/M program with an idle test covering all model years of vehicles.

A step-by-step description of the base methodology and how it was applied to the example follows and is shown in Table 2.

1. Estimate the model years and number of vehicles to be retired: For this example, the model year distribution of the participating vehicles is assumed to be identical to that of the eligible fleet and is based upon the national fleet model year distribution from MOBILE4.1. It is assumed that 10,000 pre-1980 model year vehicles are scrapped on January 1, 1993.

2. Estimate changes in fleet size: For this example, it is assumed that the total number of vehicles in the fleet remains the same as before the program was implemented.

3. Estimate changes in VMT: EPA's approach keeps total VMT the same before and after the program. The values are determined by the annual mileage accumulation in the MOBILE model and are supported by data reported by Oak Ridge National Laboratory in the Transportation Energy Data Book: Edition 11, and also by data collected by UNOCAL during the demonstration program in Los Angeles during the summer of 1990. The average VMT per year per retired vehicle is 5,182 miles in year 1, 4,920 miles in year 2 and 4,680 miles in year 3.

4. Estimate the expected number of years of use remaining for the retired vehicles: The expected number of years of use remaining in the retired vehicles is three years.

5. Estimate the average emissions per year from the retired vehicles: The average emissions from the retired vehicle were estimated by MOBILE4.1, using national average characteristics for climate, geography, local control program and vehicle fleet (e.g., altitude, fuel, I/M program, fleet, travel fraction). The MOBILE model was then run for three successive years – 1993, 1994, 1995. The average emissions were determined by running the model with zero registrations and zero mileage accumulation for 1980 and newer model years. The average grams per mile (gpm) are indicated at the bottom of the column labeled FER in the MOBILE4.1 output table. The emission levels for the retired vehicles in each of the three years were as follows: 8.87 gpm in 1993, 9.06 gpm in 1994 and 9.26 gpm in 1995.

6. Estimate the average emissions per year from the replacement vehicles: The estimates of the average emissions from the entire post-program fleet were based on the same national average characteristics mentioned above. To estimate the average emissions of the replacement vehicles, the MOBILE model should be run for all

STAPPA/ALAPCO Recommendation

► Areas should consider implementation of a vehicle scrappage program in conjunction with an I/M program.

model years for 1993, 1994 and 1995. The average grams per mile will be indicated in the column labeled FER in the MOBILE4.1 output table. The emission levels for the replacement vehicles in each of the three years were as follows: 2.20 gpm in 1993, 2.09 gpm in 1994 and 2.00 gpm in 1995.

7. Calculate the average yearly emissions benefit for each retired vehicle: Subtract the result of step 6 from the result of step 5 and multiply by the average VMT per scrapped vehicle, as determined in step 3, for each calendar year. The results are 34,564 grams/vehicle in 1993, 34,292 grams/vehicle in 1994 and 33,977 grams/vehicle in 1995.

8. Calculate the total emissions reduction in tons per year removed by the program: Multiply the average emissions benefit for each retired vehicle by the effective number of vehicles retired and convert to tons for each calendar year. To determine the effective number of vehicles for each year, reduce the number of scrapped vehicles by the "normal" retirement rate. For this example, the national rate of decline of 20 percent per year will be assumed, starting immediately after the scrappage event. Averaged over each of the three years, the effective number of vehicles for each year is 9,000, 7,200 and 5760, respectively.

FEDERAL RULEMAKING AND/OR GUIDANCE DOCUMENTS

In February 1993, EPA published guidance on the generation of mobile source emissions reduction credits and on the implementation of an accelerated retirement program for motor vehicles.

STATE AND LOCAL CONTROL EFFORTS

The South Coast Recycled Auto Project (SCRAP), sponsored by UNOCAL, is currently underway in Los Angeles, CA.

In addition, the California Air Resources Board published a document entitled Mobile Source Emission Reduction Credits (February 1993), which addresses, among other issues, the generation of emission reduction credits through the accelerated retirement of older vehicles.

REFERENCES

1. U.S. Environmental Protection Agency, Office of Mobile Sources. February 23, 1993. *Guidance on the Generation of Mobile Source Emission Reduction Credits*. 58 Federal Register 11134.
2. U.S. Environmental Protection Agency, Office of Mobile Sources. February 1993. *Guidance for the Implementation of Accelerated Retirement of Vehicles Programs*.

Table 1.....

Estimated Emissions Reductions from a Program to Retire 10,000 Vehicles in 1993

Year	Emission Reduction (tons)		
	VOC	NO _x	CO
1993	343	115	2600
1994	272	91	2085
1995	216	72	1657
Total	831	278	6342
Avg/Yr	277	93	2114

Table 2.....

Example Hydrocarbon Emission Reduction (assuming 10,000 pre-1980 model year vehicles scrapped on 1/1/93)

	1993	1994	1995
HC/retired vehicle (gpm)	8.87	9.06	9.26
HC/replacement vehicle (gpm) —	<u>2.20</u>	<u>2.09</u>	<u>2.00</u>
HC reduction/vehicle (gpm) =	6.67	6.97	7.26
VM/Year/retired vehicle x	<u>5182</u>	<u>4920</u>	<u>4680</u>
Grams/vehicle/year =	34564	34292	33977
Effective number of vehicles ^a x	9000	7200	5760
Conversion (grams to tons) x	<u>.000001102</u>	<u>#</u>	<u>#</u>
Tons per year =	343	272	216

^aThe analysis assumes that all of the retired vehicles would have been scrapped within three years. This method assumes a 20-percent scrap-page rate per year for three years and provides for no reduction credit beyond the three-year remaining life assumption.

SECTION III

Stationary and Area Source Control Strategies

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Adhesives

DESCRIPTION OF SOURCE CATEGORY

Adhesives are compounds or mixtures of compounds used to bond materials together. Adhesive formulations typically consist of a base material plus various additives, including diluents, solvents, catalysts, hardeners, inhibitors and retarders. Used widely in consumer, commercial and industrial applications, adhesives account for a relatively large percentage of area source volatile organic compound (VOC) emissions, according to the Congressional Office of Technology Assessment.

Use of consumer adhesives ranges from assembling a child's model airplane to attaching tile to the kitchen floor. The availability of adhesives has encouraged the widespread implementation of "do-it-yourself" projects, from repairing furniture to hanging wallpaper.

Commercial uses, which include building trades (attaching wall paneling, tile or PVC plumbing), also have increased significantly as newer materials become available. Industrial uses of adhesives include construction, industrial assembly, wood products industries, textile products, footwear, packaging and other miscellaneous sources, such as glass insulation, abrasive products, printing and publishing and tire manufacture.

Not all adhesives emit VOCs upon setting. There are several natural resin adhesives (gum arabic, Canada Balsam, protein and starch) that are water soluble and emit only water vapor upon drying. Epoxy adhesives and inorganic mineral material (silicate, magnesia, phosphates, sulfur and bitumen) also do not emit VOCs upon drying. In addition, there are some adhesives that contain a reactive diluent that becomes part of the product after curing.

GEOGRAPHIC DISTRIBUTION OF SOURCES

Since a significant portion of VOC emissions from adhesives are the result of human activity, the distribution of emissions sources can be assumed to be directly proportional to an area's population.

NATIONAL EMISSIONS ESTIMATES

The use of adhesives is assumed to be evenly distributed over large populations. In 1989, the California Air Resources Board (CARB) estimated that VOC emissions from the consumer and commercial use of adhesives amounted to 431 tons per year in that state. Based on a 1989 population of 29,063,000 in California, the per capita

emissions rate is estimated to be 1.483×10^{-5} tons per year per person. By extrapolating this emissions rate to the 1989 United States population (248,239,000), one arrives at a national emissions estimate from consumer products adhesives of 3,680 tons of VOCs per year. A study prepared by the U.S. Environmental Protection Agency (EPA) in the late 1970s estimated national emissions from industrial adhesives to be 605,000 tons per year. This estimate included source categories that have since been regulated by EPA, including pressure-sensitive tapes and labels and pneumatic rubber tires.

AVAILABLE CONTROL STRATEGIES

According to work done by CARB, most of the VOC content of adhesives will eventually volatilize into the atmosphere because of the way adhesives are used. The only practical way to lower VOC emissions is to reduce the VOC content of the adhesives, either through product reformulation or product substitution.

Reformulation: Solvent-based adhesives provide quick-setting, superior adhesion and compatibility with many additives. To ensure acceptance, reformulated adhesives products must exhibit these same qualities. Reformulated products contain water or an exempt organic solvent in place of a VOC solvent. However, some exempt organic solvents are being phased out because they are either hazardous air pollutants (methylene chloride or 1,1,1-trichloroethane) or ozone depleters (1,1,1-trichloroethane or chlorofluorocarbons). Reformulated adhesives come in waterborne, diluent-based and solventless varieties.

- Waterborne adhesives use water as their solvent. Water can be used in adhesives by changing to water-compatible active ingredients or by creating an emulsion system. The advantages of waterborne adhesives are that they have no harmful vapors, disagreeable odors or flammability hazards. However, to be acceptable to the user, they must have bond strengths and drying speeds comparable to those of solvent-based adhesives, without being harmful to the environment.
- Reactive diluent-based solvents contain solvents that become part of the product after curing. Therefore, little or no VOCs are emitted. This reformulation currently can be accomplished by one of two techniques. The first involves suspending solids in a VOC (such as styrene) with a catalyst that initiates a chemical reaction. The reaction produces a solid film in which the VOCs are incorporated as part of the cured adhesive. The second

STAPPA/ALAPCO Recommendation

- State and local agencies should consider adopting the CARB consumer product adhesive limits, (See Table 1), supplemented by the industrial product adhesive rules of the local air quality control districts in California (e.g., SCAQMD), specified below.

technique involves mixing two liquids that react chemically (as in polymerization) to create a solid that is part of the adhesive.

- Solventless adhesives make use of solids with low melting points and come in two forms, sheet and hot-melt. Sheet adhesive, used in flat surface applications, is laid between two panels, compressed and heated, causing the sheet to melt. The panels are bonded together as they cool. Hot-melt adhesive is a solid rod or coil that is heated with a hand-held tool and extruded to where it is needed.

A significant proportion of VOC emissions from consumer use of adhesives comes from aerosol adhesives. These emissions can be reduced by reformulating the adhesives to high-solids adhesives, using water-based formulations and/or adding a high transfer efficiency application tip. Also, VOC propellants could be replaced with nonpolluting propellants.

Product Substitution: Product substitution is defined as replacing high-content VOC adhesives with products that contain little or no VOCs. An example would be to ban aerosol adhesives (which represent only 8 percent of the market, but emit 35 percent of the VOCs from adhesives), thereby forcing consumers to use another form of adhesive.

Another option would be to replace VOC-containing adhesives with hot-melt adhesives in many applications. Inexpensive, hand-held, hot-melt adhesive units (glue guns) have been developed and are currently available to consumers. Hot-melt adhesives can be used to bond metals, plastics, laminates, electronics, wood-prod-

uct corrugated boxes, cardboard, ceramics, leather and fabrics.

POTENTIAL NATIONAL EMISSIONS REDUCTION

CARB estimates that its standard would reduce VOC emissions from consumer products adhesives by 248 tons per year. This projects to a nationwide reduction of 2,120 tons per year of household adhesives. Non-household uses of adhesives, including point sources and high-volume non-point sources (e.g., contractor uses), add significantly to the potential for reducing nationwide emissions.

COST EFFECTIVENESS

The cost effectiveness of implementing the CARB standard nationwide is estimated to be the same as the cost effectiveness for California, as shown below.

Cost Effectiveness of California Standard

(\$ per ton of VOC reduced)

Range			
Low		High	
5 years	10 years	5 years	10 years
\$60	\$40	\$800	\$540

FEDERAL RULEMAKING AND/OR GUIDANCE DOCUMENTS

EPA is not planning to develop rules or guidance for this category.

STATE AND LOCAL CONTROL EFFORTS

California leads the nation in the development of standards for reducing VOC emissions from consumer adhesives. The CARB standard is based on five adhesive groups: 1) aerosols, 2) contact cement, 3) construction and panel, 4) cyanoacrylates and 5) general purpose (all others). For aerosol adhesives, the CARB standard requires that the VOC content be less than or equal to 75 percent by 1995 and less than or equal to 25 percent by 1997. Contact cement must have a VOC content of less than or equal to 80 percent beginning on January 1, 1995, while construction and panel adhesives must meet at least a 40-percent limit by January 1, 1995. Most cyanoacrylates are exempted from the standard because of the small amount used per application and the low VOC content emitted (estimated to be only 5 percent). Finally, for general purpose adhe-

sives, the standard requires the VOC content to be less than or equal to 10 percent by January 1, 1995.

Other agencies regulate VOC emissions from industrial adhesives. For example, the South Coast Air Quality Management District's (SCAQMD's) Rule 1168 establishes interim and final limits that can be achieved through product reformulations, product substitution, transfer efficiency improvement or add-on control equipment. The VOC emission inventory in 1987 for the application of adhesives in the SCAQMD was estimated at 45 tons per day. With full implementation of Rule 1168, the VOC emissions reduction is expected to reach 40 tons per day, or 90 percent, by 1998.

REFERENCES

1. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. September 1992. *Volatile Organic Compound Emissions from Consumer and Commercial Products, Adhesive and Sealants*. Draft Report to Congress.
2. California Air Resources Board. October 1991. *Proposed Amendments to the Consumer Products Regulation, Phase II*. Technical Support Document and Appendices.

Table 1.....
CARB Consumer Product Adhesive Limits

Category	Percentage VOCs By Weight (1/1/95)
Aerosol	75 (25 by 1/1/97)
Contact	80
Construction and Panel	40
General Purpose	10

Table 2

SCAQMD Industrial Product Adhesive Rule

- (1) After January 1, 1993, a person shall not apply adhesives, adhesive bonding primers, adhesive primers or any other primers that have a VOC content in excess of 250 grams per liter less water and exempt compounds, unless otherwise specified below.
- (2) A person shall not apply adhesives, adhesive bonding primers, adhesive primers or any other primers that have a VOC content in excess of the limits specified below.

SCAQMD Industrial Product Adhesive Limits

- (A) For adhesives, adhesive bonding primers, adhesive primers or any other primer used in the following welding or installation operations:

VOC Limit - Less Water and Exempt Compounds
(grams per liter)

Operation	Effective 1/1/93	Effective 1/1/94	Effective 1/1/98
Non-Vinyl-Backed Indoor			
Carpet Installation	150	150	150
Carpet Pad Installation	150	150	150
Wood Flooring Installation	150	150	150
Ceramic Tile Installation	130	130	130
Dry Wall & Panel Installation	200	200	200
Subfloor Installation	200	200	200
Rubber Floor Installation	150	150	150
VCT & Asphalt Tile Installation	150	150	150
PVC Welding	850	450	250
CPVC Welding	850	450	250
ABS Welding	850	350	350
Plastic Cement Welding	850	350	250
Cove Base Installation	150	150	150
Adhesive Primer for Plastic	650	650	250
Computer Diskette Mfg			350

Table 2 – continued

- (B) For adhesives, adhesive bonding primers or any other primers not regulated by category (A) and applied to the following substrates, the following limits shall apply:

VOC Limit - Less Water and Exempt Compounds
(grams per liter)

Substrate	Effective 1/1/93
Metal to Metal	30
Plastic Foams	120
Porous Material (except wood)	120
Wood	30
Fiberglass	200

ADHESIVES

Table 3

Summary Table – Adhesives

Affected Facilities	Any individual using VOC-emitting adhesives.
Number of Affected Facilities	Any of the approximately 250 million people living in the United States could engage in a "do-it-yourself" project using consumer adhesives.
National Emissions Estimate	Extrapolating CARB's estimates for California, about 3,680 tons of VOC per year are emitted from consumer adhesives. Industrial adhesives increase estimates significantly.
Potential National Emissions Reduction	If the CARB consumer adhesive standards were applied nationwide, emissions could be reduced by 2,120 tons per year, or about 58 percent.
Potential Emissions Reduction Per Facility	VOC reduction overall, and per facility, could be 58 percent for consumer adhesives.
Cost Effectiveness	CARB estimates cost effectiveness to be between \$60 and \$800 per ton of VOC removed from consumer adhesives.
Federal Rulemaking and/or Guidance Documents	EPA does not intend to develop rules or guidance for this category.
State and Local Control Efforts	CARB has proposed a VOC content of 75 percent or less by 1995 and 25 percent or less by 1997 for aerosol adhesives. SCAQMD Rule 1168 establishes interim and final limits to reduce VOC emissions from industrial adhesives. The limits can be achieved through product reformulations, product substitution, transfer efficiency improvement or add-on control equipment. The VOC emission inventory in 1987 for the application of adhesives in SCAQMD was estimated to be 45 tons per day. With full implementation of Rule 1168, the VOC emissions reduction is expected to reach 40 tons per day, or 90 percent, by 1998.
STAPPA/ALAPCO Recommendation	Consider adopting the consumer product adhesive limits of CARB, supplemented by the industrial product adhesive limits of SCAQMD.

Aerosol Paints

DESCRIPTION OF SOURCE CATEGORY

Aerosol spray paints are a subcategory of consumer and commercial products and include a wide variety of paint and coating products, such as, among others, general flat and enamel paints, hobby paints, automotive exact-match paints and fluorescent paints. A typical aerosol spray paint consists of the paint resin and pigment (solids) additives, solvents and propellants. Aerosol paints are used widely by homeowners, industry, commercial operations, artists and hobbyists.

GEOGRAPHIC DISTRIBUTION OF SOURCES

Aerosol spray paints are distributed nationally, with the volume of distribution generally proportional to population.

NATIONAL EMISSIONS ESTIMATES

According to the U.S. Environmental Protection Agency (EPA), aerosol spray paints are responsible for approximately 158,000 tons of volatile organic compound (VOC) emissions per year.

AVAILABLE CONTROL STRATEGIES

The primary method of decreasing the VOC content of aerosol paints is through reformulation. There are several ways of reformulating paints, including conversion to a high-solids paint, conversion to a water-based paint, reduction in the solvent by changing the resin type or substitution of a non-VOC propellant, such as HFC-152a or compressed air.

POTENTIAL NATIONAL EMISSIONS REDUCTION

Assuming that aerosol paint distribution is similar throughout the country, if the Bay Area Air Quality Management District's (BAAQMD's) aerosol paint rule were adopted nationwide, the emissions reductions would be approximately 20 percent. Inclusion of a second tier of VOC limits could increase the emissions reductions further.

FEDERAL RULEMAKING AND/OR GUIDANCE DOCUMENTS

Section 183(e) of the Clean Air Act requires EPA to conduct a study of commercial and consumer products. Based on the study, EPA is required to divide this category into four groups and regulate one set every two years until all four are regulated. It is not now known which consumer and commercial products will be regulated or if EPA will choose instead to issue a Control Techniques Guideline in lieu of a federal regulation.

❖ For more information on EPA programs in this area, contact Bruce Moore, U.S. Environmental Protection Agency, Emission Standards Division (MD-13), Research Triangle Park, NC 27711 (telephone: 919/541-0283).

STATE AND LOCAL CONTROL EFFORTS

Two local air districts in California have adopted aerosol paint rules and the California Air Resources Board (CARB) is currently developing a state-wide rule. BAAQMD and the South Coast Air Quality Management District (SCAQMD) each have regulations limiting the VOC content of aerosol paints. The BAAQMD Regulation 8, Rule 42, "Aerosol Paint Products," establishes limits on 34 different categories of aerosol paints and achieves a VOC emissions reduction of approximately 20 percent. SCAQMD is proposing to amend its Rule 1129, "Aerosol Coatings," in a manner similar to the BAAQMD standards; however, it is also considering the addition of standards to be effective in the future to achieve an overall 60-percent reduction in VOC emissions from aerosol spray paints. CARB is currently developing a proposed rule that will initially achieve a VOC emissions reduction of approximately 20 percent, followed by a second tier of requirements that would increase the total reductions to 30-35 percent.

REFERENCES

1. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. July 1992. *Volatile Organic Compound Emissions from Consumer and Commercial Products - Aerosol Spray Paints*. Draft.

STAPPA/ALAPCO Recommendation

► State and local agencies should consider adopting the BAAQMD aerosol paint rule. A summary of the key provisions of the BAAQMD rule is provided in Table 1. Adoption of this rule would result in emissions reductions in the aerosol paint inventory of approximately 20 percent. If additional emissions reductions are necessary, state and local agencies may wish to pursue a second set of standards to be effective in the future, similar to the SCAQMD approach.

Table 1.....

Selected Provisions of Bay Area Air Quality Management District Aerosol Paint Rule

8-49-300 STANDARDS

8-49-301 Limits: A person shall not sell, offer for sale, apply, solicit or manufacture for sale within the BAAQMD any hand-held aerosol paint product with a VOC content in excess of the following limits, expressed as percent VOC by weight of product:

301.1 General Coatings	VOC Limits (%)
Clear Coating	67
Flat Paint Products	60
Fluorescent	65
Ground Traffic Market Coating	66
Metallic Coating	80
Non-Flat Paint Products	65
Primer	60

301.2 Specialty Coatings

301.2.1 Specialty Clear and Tinted Coatings

Corrosion Resistant Brass/Bronze/ Copper Coating	92
Photographic Emulsion Coating	95
Art Varnish	92
Marine Spar Varnish	92
Vinyl/Fabric/Polycarbonate	95
Webbing/Veiling Coating	95
Wood Stain	95
Workable Art Fixative	95

-continued

Table 1--continued

301.2.2 Exact Match Finish	VOC Limits (%)
Engine Enamel	80
Automotive	88
Industrial	88
301.2.3 Miscellaneous Coatings	
Auto Body Primer	80
High Temperature Coating	80
Hobby/Model/Craft Coatings	
Enamel	80
Lacquer	88
Clear Metallic	95
Shellac Sealer	
Clear	88
Pigmented	75
Spatter Coating	80
301.3 Non-Retail Specialty Coatings	
Automotive Bumper and Trim Products	95
Aviation Propeller Coating	84
Aviation Zinc Primer	82
Floral Spray	95
Glass Coating	95
Slip-resistant Epoxy Coating	85
Weld-through Primer	75
Wood Touch-up/Repair/Restoration	95

(Amended August 21, 1991)

Table 2

Summary Table – Aerosol Paints

Affected Facilities	General flat and enamel paints, hobby paints, automotive exact-match paints, fluorescent paints and others.
Number of Affected Facilities	Aerosol spray paints are distributed nationally; the volume of distribution is generally proportional to population.
National Emissions Estimates	EPA estimates VOC emissions of approximately 158,000 tons per year.
Potential National Emissions Reduction	Implementation of the BAAQMD aerosol paint rule nationally could result in emissions reductions of approximately 20 percent. A second tier of VOC limits could increase the reductions to 30-35 percent (California's effort) or 60 percent (the SCAQMD approach).
Federal Rulemaking and/or Guidance Documents	Section 183(e) of the Clean Air Act calls for EPA to study consumer and commercial products. Based on the study, EPA must divide the category into four groups and regulate one set every two years until all four are regulated. It is unknown which products will be regulated or if EPA will instead issue a Control Techniques Guideline.
State and Local Control Efforts	Two local agencies in California, the BAAQMD and the SCAQMD, have adopted rules to limit the VOC content of aerosol paints. California is developing a state-wide rule.
STAPPA/ALAPCO Recommendation	Consider adopting the BAAQMD rule. If additional reductions are needed, agencies may pursue a second set of standards similar to those of SCAQMD.

Aerospace Manufacturing and Rework Industry

DESCRIPTION OF SOURCE CATEGORY

An aerospace vehicle or component is defined as any fabricated part, processed part, assembly of parts or completed unit of any aircraft, including airplanes, helicopters, missiles, rockets and space vehicles. Aerospace manufacturing and rework operations include any manufacturing operation that produces an aerospace vehicle or component and any rework operation that reworks or repairs these aerospace vehicles or components. In addition to manufacturing and rework facilities, some shops may specialize in providing a service, such as chemical milling, rather than actually producing a component or assembly.

The nine Standard Industrial Classification (SIC) codes that address aerospace manufacturing and rework operations are:

- 3720 Aircraft and Parts**
- 3721 Aircraft**
- 3724 Aircraft Engines and Engine Parts**
- 3728 Aircraft Parts and Equipment**
- 3760 Guided Missiles, Space Vehicles and Parts**
- 3761 Guided Missiles and Space Vehicles**

- 3764 Space Propulsion Units and Parts**
- 3769 Space Vehicle Equipment**
- 4581 Airports, Flying Fields and Services**

Facilities that are classified under one or more of these SIC codes may be subject to volatile organic compound (VOC) controls, as may certain other facilities that produce, rework or repair aerospace vehicles or components.

GEOGRAPHIC DISTRIBUTION OF SOURCES

There are an estimated 2,487 commercial and 492 military aerospace manufacturing and rework facilities in the United States. In addition, there are numerous subcontractors that are not classified under aerospace manufacturing SIC codes that manufacture or rework aerospace components. The Boeing Company alone, for example, employs more than 5,000 subcontractors which could be subject to regulation if it meets size cutoffs.

Aerospace manufacturing facilities and rework operations are typically located in or near industrial centers in areas of medium to high population density. States with large numbers of aerospace manufacturers include Califor-

nia (870), Connecticut (257), Texas (233), Florida (214) and Washington (214).

NATIONAL EMISSIONS ESTIMATES

The U.S. Environmental Protection Agency (EPA) estimates that 300,000 tons per year of hazardous air pollutants (HAPs) and 200,000 tons per year of VOCs are emitted from the aerospace industry. Predominant HAPs that are also VOCs include methyl ethyl ketone, xylene, toluene, trichloroethylene, glycol ethers, ethylene glycol and methyl isobutyl ketone. Because there is little quantitative data available for VOCs in this industry, much of the data reported in this chapter addresses emissions of HAPs.

AVAILABLE CONTROL STRATEGIES

EPA is considering the following Maximum Achievable Control Technology (MACT) floors and regulatory options for the aerospace manufacturing industry:

- **Hand Wipe and Flush Cleaning:**
 - vapor pressure limit of 45 millimeters of mercury (mmHg) at 20°C
 - evaporation rate limit of 1.0 (butyl acetate = 1)
 - solvent-laden rags stored in closed containers
 - solvent stored in closed containers
- **Spray Gun Cleaning:**
 - enclosed spray gun cleaners
 - unatomized spraying of solvent into a waste container that is kept closed when not in use
 - hand cleaning in a vat that is kept closed when not in use
 - atomized spraying using a cyclonic capture device
 - hand cleaning for the exterior of guns, the seats under the caps and when periodic maintenance is required
- **Primers and Topcoats:**
 - high transfer efficiency application methods for primer and topcoat application
 - Best Available Control Measures (BACM) limits for coatings and specialty coatings (see Tables 1 and 2, respectively; section 183 (a)(3) of the Clean Air Act specifies that the CTG for aerospace coatings be based on Best Available Control Measures [BACM], not RACT)
- **Commercial and Civil Aircraft Depainting:**
 - no hazardous air pollutant emissions allowed

STAPPA/ALAPCO Recommendation

► State and local agencies should set regulations no less stringent than the NESHAP currently under development by EPA. Agencies should be aware that EPA's recommendations for specialty coatings represent the status quo for aerospace operations and are, in essence, exemptions from control. Areas should tailor their limits for specialty coatings to reflect local plant line-by-line operations.

from chemical depainting
• exemptions for spot, decal and parts stripping

- **Military Aircraft Depainting:**
 - no HAP emissions allowed from chemical depainting
 - exemptions for spot, decal and parts stripping

- **Chemical Milling Maskant:**
 - 1.3 pounds of HAPs per gallon, less water of maskant as applied

POTENTIAL NATIONAL EMISSIONS REDUCTION

EPA estimates that promulgation of the National Emission Standards for Hazardous Air Pollutants (NESHAP) for aerospace manufacturing will reduce HAP emissions by 196,000 tons per year. To date, EPA has not estimated VOC emissions reductions.

The MACT floors and regulatory options currently under consideration by EPA would produce the following reductions in HAP emissions:

- Hand Wipe and Flush Cleaning
127,000 tons/year (80 percent)
- Spray Gun Cleaning
730 tons/year (73 percent)
- Primers
4,560 tons/year (90 percent)
- Topcoats
4,040 tons/year (90 percent)

- Commercial and Civil Aircraft
84,300 tons/year (80 percent) Depainting
- Military Aircraft Depainting
18,800 tons/year (100 percent)
- Chemical Milling Maskant
2,690 tons/year (80 percent)

COST EFFECTIVENESS

The cost effectiveness of the MACT floors and regulatory options under consideration by EPA is as follows:

- Hand Wipe and Flush Cleaning
\$5,200 savings/ton VOC reduced
- Spray Gun Cleaning.
\$78,000 savings/ton VOC reduced
- Primers
\$16,400 savings/ton VOC reduced
- Topcoats
\$16,400 savings/ton VOC reduced
- Commercial and Civil Aircraft Depainting
\$19,800 savings/ton VOC reduced
- Military Aircraft Depainting
\$780/ton VOC reduced
- Chemical Milling Maskant
\$8,700/ton VOC reduced

FEDERAL RULEMAKING AND/OR GUIDANCE DOCUMENTS

The aerospace manufacturing and rework industry is currently regulated under the Control Techniques Guideline (CTG) for surface coating of miscellaneous parts and products.

EPA's Emission Standards Division is developing a NESHAP and a new CTG specifically for the aerospace manufacturing and rework industry; the proposed NESHAP and the draft CTG are expected to be published in July 1994, with final documents expected in July 1995.

There is a large overlap between aerospace processes that emit HAPs and those that emit VOCs. This is especially true in aerospace coating operations. Accordingly, EPA is coordinating the development of the NESHAP and the CTG in order to ensure a consistent regulatory strategy for reducing emissions.

❖ For more information, contact Vickie Boothe, U.S. Environmental Protection Agency, Emission Standards Division (MD-13), Research Triangle Park, NC 27711

(telephone: 919/541-0164).

STATE AND LOCAL CONTROL EFFORTS

Eleven state and local agencies have adopted regulations specifically for the control of emissions from aerospace manufacturing and rework operations; they include California (Los Angeles, San Diego, San Francisco, Ventura), Alabama, Connecticut, Oklahoma, Texas, Missouri, Washington and New York. Nine other states apply the limits specified under EPA's CTG for miscellaneous metal parts and products, with or without exemptions for specialty aerospace coatings.

REFERENCES

1. U.S. Environmental Protection Agency. Office of Air Quality Planning and Standards. November 1992. *National Emission Standard for Hazardous Air Pollutants (NESHAP) for the Aerospace Industry - Background Information for Proposed Standards. Draft.*
2. U.S. Environmental Protection Agency. Office of Air Quality Planning and Standards. May 4-5, 1993. *National Emission Standard for Hazardous Air Pollutants and Control Techniques Guidelines for the Aerospace Industry - EPA Roundtable Discussion.*
3. U.S. Environmental Protection Agency. Office of Air Quality Planning and Standards. June 16, 1993. *NESHAP for the Aerospace Manufacturing and Rework Industry - Work Group Option Selection Meeting.*

Table 1

BACM For Coatings

(lbs VOCs/gal, less water and exempt solvents)

Coating	Commercial	Military
Topcoats	3.5	3.5
Primers	2.9	2.9
Sealants - Hand Applied	0.5	0.5
Sealants - Spray Applied	3.8	3.8
Adhesives - Structural	0.5	0.5
Adhesives - Nonstructural	3.0	2.6
Adhesives - Rubber-Based		
Interior	6.3	-
All others	5.8	5.8
Adhesive Bonding Primers	5.5	5.5

Table 2**BACM For Specialty Coatings^a***(lbs VOCs/gal less water and exempt solvents)*

Specialty Coating	Commercial	Military
Abrasive	5.0	5.0
Antichafe	5.5	5.5
Ballistic Liner	4.0	4.0
Clear	4.4	4.4
Compatible Substrate Primer	6.5	6.5
Corrosion Prevention Compound	5.9	5.9
Electric or Radiation Effect	6.7	6.7
Electrostatic Discharge	6.7	6.7
Enamel	5.5	5.5
Fire Resistant (Interior)	6.7	3.0
Flexible Primer	5.3	5.3
Flight Test		
Missile or Single-use Aircraft	3.5	3.5
All Other	7.0	7.0
Fuel Tank	6.0	6.0
High Temperature	7.1	7.1
Impact Resistant	5.0	5.0
Inks		
Screen Printing	7.0	6.3
Part Marking (includes temporary marking and stencil)	7.1	7.1
Insulation	5.9	5.9
Lacquers	6.9	6.9
Metalized Epoxy		
Zinc-filled	4.0	4.0
All others	6.2	6.2
Mold Release	6.5	6.5
Optical Anti-reflection	5.8	5.8
Pretreatment	6.5	6.5
Protective Oils/Waxes	7.0	7.0
Rain Erosion Resistant	6.7	6.7
Space Vehicle	7.4	7.4
Specialized Function	7.4	7.4
Temporary Protective	2.7	2.7
Wing	6.5	6.5

^aSpecialty coatings are defined as coatings designed to fulfill extremely specific engineering requirements, limited in application and characterized by low-volume usage. Due to the specialized nature and low usage of these coatings, low HAP/VOC substitutes are typically not available. In many cases, there is only one coating available within a specialty coating category. Twenty-seven specialty coating categories have been identified. Total HAP emissions from these specialty coatings represent approximately 1.4 percent of the total HAP emissions generated by the aerospace industry. For the few specialty coatings for which substitutes may exist, the emissions reduction potential is very small. Considering the requalification cost to industry to implement these substitutes, the cost effectiveness is extremely unfavorable. Consequently, the VOC limits for specialty coatings represent the current VOC levels in use by the industry.

Table 3

Summary Table – Aerospace Manufacturing and Rework Industry

Affected Facilities	<p>The nine Standard Industrial Classification codes that address aerospace manufacturing and rework operations are:</p> <p>3720 Aircraft and Parts 3721 Aircraft 3724 Aircraft Engines and Engine Parts 3728 Aircraft Parts and Equipment 3760 Guided Missiles, Space Vehicles and Parts 3761 Guided Missiles and Space Vehicles 3764 Space Propulsion Units and Parts 3769 Space Vehicle Equipment 4581 Airports, Flying Fields and Services</p>			
Number of Affected Facilities	There are an estimated 2,487 commercial and 492 military aerospace manufacturing and rework facilities in the United States. There is also an unknown number of subcontractors that are not classified under aerospace manufacturing SIC codes that manufacture or rework aerospace components.			
National Emissions Estimates	EPA estimates that 300,000 tons per year of HAPs and 200,000 tons per year of VOCs are emitted from the aerospace industry. Pre dominant HAPs that are also considered to be VOCs include methyl ethyl ketone, xylene, toluene, trichloroethylene, glycol ethers, ethylene glycol and methyl isobutyl ketone.			
Potential Emissions Reduction Per Facility-HAP (tpy)		Small	Medium	Large
	Coating Application for Primers & Topcoats	0.31-0.61	1.20-2.15	10.26-18.29
	Spray Equipment Cleaning	0.22	0.26	0.29
	Military Aircraft Depainting	212.8	294.0	1,592.9
	Commercial Aircraft Depainting	21.3	54.3	No Data
	Hand Wipe Cleaning	2.3	62.6	281.9
	Chemical Milling Maskant	No Data	28.2-47.0	61.1-101.9
Potential Emissions Reduction Per Facility-VOC	Emission reductions range from 73 percent for spray gun cleaning to 100 percent for military aircraft depainting.			
Cost Effectiveness	Costs range from a savings of \$78,000/ton for spray gun cleaning, to a cost of \$8,700/ton for chemical milling maskant.			
Federal Rulemaking and/or Guidance Documents	EPA is currently developing a NESHAP and CTG for the aerospace manufacturing and rework industry. A NESHAP proposal and draft CTG are expected in July 1994, with final documents expected in July 1995.			
State and Local Control Efforts	At least 11 state and local agencies have regulations for aerospace manufacturing.			
STAPPA/ALAPCO Recommendation	Set regulations no less stringent than the NESHAP currently under development by EPA. State and local agencies should be aware that EPA's recommendations for specialty coatings represent the status quo for aerospace operations and are, in essence, exemptions from control. Areas should tailor their limits for specialty coatings to reflect local plant line-by-line operations.			

Aluminum Rolling Mills

DESCRIPTION OF SOURCE CATEGORY

There are two basic types of aluminum rolling processes: hot rolling and cold rolling. Aluminum hot rolling is performed above the recrystallization temperature of the alloy being processed (572°F to 896°F). Hot mills produce bars, plates, rods and sheets directly from cast aluminum ingots. Cold rolling, which is performed at temperatures below 212°F, converts aluminum raw materials into many consumer aluminum products, including light-gauge aluminum sheet and foil. VOC emissions result from the use of kerosene-based lubricants in the rolling process. A cold mill is used to reduce the thickness of aluminum as it passes between two-high or four-high rolling mills. During aluminum thickness reduction, heat is generated on the surface of the cold rollers. This heat must be controlled in order to ensure uniform gauge across the aluminum strip. Rolling mill lubricant removes the heat from the surface of the rollers and reduces the coefficient of friction between the steel rollers and the aluminum product. The lubricant is supplied to the roll in excess and the overflow is collected, cooled and filtered before being recycled.

Volatile organic compound (VOC) emissions generated at cold-rolling mills consist primarily of vapor and

aerosol forms of the rolling mill lubricant. These emissions are normally captured by hood exhaust systems. Many factors affect the emissions levels produced by an individual cold-rolling mill and by an entire plant. These factors include:

- the physical and chemical properties of the base oil and lubricant additives (i.e., volatility, specific heat, and heat of vaporization);
- the oil temperature;
- the amount of heat generated during rolling;
- the mill production rate (mill speed);
- the magnitude of size reduction per pass;
- the type of mill (e.g., breakdown, finishing);
- the method of oil application and the application rate; and
- the gas velocity at the face of the collection hood.

The type of product being manufactured determines many of the process parameters that directly affect VOC emissions. For example, the type of lubricant used and the lubricant properties desired are determined largely by

product specifications. Lubricant properties that are most relevant to emissions control are vapor pressure, boiling point range, specific heat and the heat of vaporization.

VOC emissions rates are also affected by the method used to apply the lubricant at the rollers. Spraying lubricant through a nozzle increases the potential for VOC emissions because the oil is partially atomized by the spraying process; atomized oil is more likely to be vaporized and lost as an emission because of the greater surface area available for evaporation. Drip and flooding are two additional application methods used to supply lubricant to the roller working area. The lubricant application method used at a particular cold mill is determined by the product being manufactured, the mill speed and the desired thickness reduction.

GEOGRAPHIC DISTRIBUTION OF SOURCES

Aluminum rolling mills are located throughout the United States.

AVAILABLE CONTROL STRATEGIES

There are two demonstrated techniques available for reducing VOC emissions from aluminum rolling mills: process modification and add-on control devices (i.e., oil scrubbers and carbon bed adsorption systems).

Process Modification: VOC emissions can be reduced by using linear paraffin rolling oil instead of the kerosene lubricant currently used. Linear paraffin oil has been used as a substitute lubricant in a Kaiser (California) rolling mill plant. It is a commercially available, high-purity paraffinic solvent containing greater than 98 percent normal paraffins ranging from C12 - C14 (n-dodecane to n-tetradecane). Aluminum foil producers in Spain have used C12H30 (n-tetradecane), a linear paraffin oil, to roll aluminum sheet and foil. Substitution of linear paraffin oil for kerosene may not be applicable to all rolling mills because lubricant formulations differ for different mills. The applicability of lubricant substitution as a VOC control technique will vary on a mill-by-mill and product-by-product basis.

The Kaiser plant achieved a 63-percent emissions reduction using linear paraffin. An emission reduction of 10 to 30 percent can be achieved by reducing the specific heat and the heat of vaporization. The temperature required to heat a given weight of linear paraffin rolling oil ranges from 100°F to 150°F, which is 10 to 30 percent higher than the temperature needed to heat a kerosene lubricant. Incorporating various additives to enhance and modify the linear paraffin oil's lubricating characteristics may also lower the linear paraffin's vapor pressure. Lower

vapor pressures result in less evaporation, thus reducing VOC emissions.

Add-on Controls: The use of scrubbers has also been demonstrated to reduce VOC emissions from aluminum rolling. In oil absorption systems, rolling mill exhaust gas flows countercurrently to heavy wash oil (or absorber oil) in a screen tray column. VOC vapors and aerosols are absorbed from the gas stream into the wash oil. The collected lubricant is separated from the wash oil by means of a two-stage, continuous vacuum distillation system. The separated lubricant is condensed in a heat exchanger and stored for reuse. The performance of oil absorbers on cold-rolling mills is dependent on the inlet VOC concentration and the amount of lubricant remaining in the wash oil. Both of these factors affect the rate of mass transfer of VOC into the wash oil. A typical absorption system is about 20 feet tall and requires a horizontal floor area of approximately 40 by 50 feet. This space requirement must be taken into consideration in retrofit situations.

Another add-on VOC emissions control technique is carbon adsorption, using either a fixed-bed or fluidized-bed configuration. Fixed-bed systems are typically operated in a batch mode, while fluidized systems are continuous. Important factors affecting the performance of carbon bed adsorbers include the amount of entrained aerosols and the relative amount of high-boiling compounds in the inlet gas. Aerosols in the gas stream will needlessly consume carbon adsorption capacity and require more frequent regeneration cycles of the carbon. Aerosols can be removed upstream of the adsorber with a mist eliminator. High boiling compounds in the gas stream will be adsorbed on the carbon bed and are not easily removed during regeneration. This continuous buildup of high-boiling compounds on the carbon bed greatly reduces operating capacity and eventually requires total replacement of the bed. It is possible to reduce the adsorption of high-boiling compounds with a "guard bed" that acts as a sacrificial device; this preadsorbing bed is replaced more often than the entire bed.

POTENTIAL NATIONAL EMISSIONS REDUCTION

Of the control techniques considered (lubricant substitution, oil absorption and carbon adsorption), lubricant substitution with linear paraffin oil appears to be the most promising. While it is difficult to make national estimates of potential VOC emissions reductions, it is easier to calculate the potential at specific plants. For example, at least two cold-rolling mills have used lubricant substitution (in Spain and California), with one (a Kaiser plant in California) achieving a 63-percent VOC emissions reduction.

STAPPA/ALAPCO Recommendation

► State and local agencies should consider requiring add-on controls achieving a 95-percent reduction in VOC emissions. Agencies may wish to exempt from control requirements mills that use a lubricant having a VOC partial pressure of 20 mmHg or less at 20°C or containing 50 grams or less VOC per liter, less water and solvent.

The oil absorption system has been demonstrated to be capable of achieving an emissions reduction of 90 percent on an inlet VOC concentration of 80 parts per million in a gas flow rate of 70,000 actual cubic feet per minute (acfm). The capture efficiency was not reported.

The degree of emissions reduction achievable with carbon adsorption systems ranges from 85 to 99 percent, depending on the specific hydrocarbon adsorbed and the desorption conditions. No data are available that pertain specifically to the VOC emissions reduction that can be achieved through the use of carbon adsorbers at rolling mills.

COST EFFECTIVENESS

Table 1 presents EPA's cost-effectiveness values for lubricant substitution, based on a model rolling mill; the model mill operates 8,760 hours per year, emits 200 tons per year of VOCs and has linear paraffin costs that are 186 percent more than kerosene lubricant costs. The substitution of linear paraffin oil for kerosene-based lubricant entails research and development costs that have not been factored into these cost-effectiveness calculations. Before lubrication substitution could be implemented on a wide scale, studies would be needed to determine the proper additives necessary to obtain the desired product quality at reasonable production rates, the effects of the substitution on downstream processes (e.g., annealing, printing and laminating) and customer acceptance.

Add-on control system costs, shown in Table 2, are influenced by a reported \$7.5-million plant shutdown cost over a five-week period during control system installation

for either oil absorption or carbon adsorption. Cost-effectiveness values are based on a control efficiency of 90 percent using oil absorption and 85 percent using carbon adsorption. Equipment costs for both add-on systems is based on a 90,000 acfm gas flow rate. This flow rate will allow for control of four to six rolling mills. Operating costs for an oil absorption system were based on a preliminary process design because data on the actual operating costs of an existing system are not available.

Operating costs of a fluidized-bed carbon adsorption system were based on the equipment vendor offering this system in the United States. A fluidized bed was selected over a fixed bed because it has been shown that operating costs for this system are less than those for fixed beds. Cost-effectiveness values were calculated using both oil absorption and carbon adsorption emissions control systems for two operating plants. The disparity in cost-effectiveness values between Plant 1 and Plant 2 demonstrate the difficulty of developing a model rolling mill plant. Differences in equipment and the production effort can account for major differences in cost-effectiveness values.

FEDERAL RULEMAKING AND/OR GUIDANCE DOCUMENTS

EPA has not developed a federal rule for aluminum rolling mills.

STATE AND LOCAL CONTROL EFFORTS

The South Coast Air Quality Management District (SCAQMD) regulates rolling mills using lubricants having greater than 50 grams of VOCs by requiring either control equipment or process control. SCAQMD exempts rolling equipment from permitting provided that any lubricants used have 50 grams or less VOC per liter of material or a VOC composite partial pressure of 20 millimeters of mercury (mmHg) or less at 20°C.

Illinois has special permit conditions for aluminum rolling mills, which require use of a no-oil system.

REFERENCES

1. U.S. Environmental Protecting Agency. December 1982. *Volatile Organic Compound Control at Specific Sources in Louisville, KY, and Nashville, TN.* EPA-904/9-81-087.

Table 1**Cost-Effectiveness Values for Lubricant Substitution^a**

Emission Reduction (%)	Annual Lubricant Losses (tons/year)	Annual Costs (1981 \$)	Cost Effectiveness (\$/ton VOC)
10	180	69,640	3,480
20	160	57,700	1,440
30	140	45,770	763
40	120	33,840	423
50	100	21,940	219
60	80	10,010	83

^a See Reference 1.**Table 2****Cost-Effectiveness Values for Oil Absorption and Carbon Adsorption^a**

Control Method	Plant	Cost Effectiveness (\$/Ton VOC controlled)
Oil absorption	Plant 1	7,140
	Plant 2	17,400
Carbon adsorption	Plant 1	7,200
	Plant 2	16,100

^a See Reference 1.

Architectural and Industrial Maintenance Coatings

DESCRIPTION OF SOURCE CATEGORY

Architectural and industrial maintenance (AIM) coatings are field-applied coatings used by industry, contractors and homeowners to coat stationary structures such as buildings, houses and their appurtenances. The various types of AIM coatings include flat and nonflat coatings (trade sales paints) and about 35 categories of specialty coatings (see Table 1 for a listing of categories). Volatile organic compound (VOC) emissions occur primarily from the evaporation of organic solvents from the coating during application and drying.

GEOGRAPHIC DISTRIBUTION OF SOURCES

AIM coatings are an area source of VOCs with emissions proportional to the population of the area. According to the U. S. Census of Paint and Allied Product Manufacturers, 634 million gallons of AIM coatings at a value of \$5,689 million were shipped from approximately 550 manufacturers in 1990.

NATIONAL EMISSIONS ESTIMATES

Based on a survey of AIM manufacturers conducted by the National Paint and Coatings Association (NPCA) in the fall of 1992, AIM coatings are estimated to contribute approximately 500,000 tons of VOCs per year nationwide or about four pounds of VOCs per person per year. Dividing this estimate by the population of the United States in 1990 (248,372,000) yields an emission factor of 4.0 lb. VOC/person/year.

Based on the NPCA data, flat and nonflat coatings account for only about 30 percent of emissions from AIM coatings, even though they represent about 60 percent of AIM coating sales. Similarly, according to a California Air Resources Board (CARB) survey of AIM coating manufacturer sales in California in 1988, flat and nonflat coatings contribute 32 percent of the emissions and 67 percent of the sales of AIM coatings. Specialty coatings, which typically have higher VOC contents than flat and nonflat coatings, account for about 30-40 percent of AIM coating sales and 60-70 percent of VOC emissions.

AVAILABLE CONTROL STRATEGIES

Because AIM coatings are typically ubiquitous, small emissions sources, the use of add-on control equipment is technically and economically infeasible. Therefore, reductions in VOC emissions must be achieved through the use of product reformulation, product substitution and consumer education.

Product reformulation is the process of altering the formulation of an existing coating to lower the VOC content. Product reformulation may involve one or more of the following strategies:

- replacing VOC solvents with water or other non-VOC solvents;
- increasing the solids content of the coating;
- altering the chemistry of the resin (or binder) so that less solvent is needed to give the coating the proper viscosity; or
- switching to a waterborne latex or water-soluble resin system.

The feasibility of these VOC-reduction strategies will depend upon the performance requirements of the coating and the size of the reduction desired.

Product substitution is the replacement of higher-VOC coatings with lower-VOC coatings or replacing AIM coatings with products that do not contain any VOCs and/or do not require recoating, such as vinyl or aluminum siding or wallpaper. To be considered a feasible alternative, lower-VOC coating products or substitutes must offer similar performance characteristics to the higher-VOC products they are replacing, at a comparable cost.

Consumer education also plays an important role in reducing VOC emissions, particularly since many consumers use higher-VOC AIM coatings unnecessarily or excessively. Accordingly, consumer education programs should include information on availability, performance and relative cost of lower-VOC coatings, low-VOC and no-VOC alternatives and appropriate surface preparation and application techniques. Such a program could also include product labels, information pamphlets (available at places of purchase) and appropriate media coverage.

POTENTIAL NATIONAL EMISSIONS REDUCTION

Emissions reductions will depend on the VOC limits chosen. Three sources of information provide some perspective on the amount of reductions that are achievable. If the 1989 CARB model rule limits were required nationwide, VOC emissions would be reduced by approximately 20 percent, compared to 1990 baseline emissions. More

STAPPA/ALAPCO Recommendation

► State and local agencies have two viable regulatory options to consider and should adopt the measure that best suits their needs. The options include, 1) the rule resulting from the National Regulatory Negotiation for Architectural and Industrial Maintenance Coatings and 2) the CARB/California Air Pollution Control Officials Association Suggested Control Measure (SCM) for Architectural Coatings.

Over the past 18 months, EPA has convened a regulatory negotiation to develop a national rule for AIM coatings. As the regulatory negotiation nears completion, it is likely that the final agreement will yield a 45-percent reduction in VOC emissions (based upon the 1990 inventory and net of growth). The regulatory structure will have three-tiers. The first tier will require a 25-percent reduction in VOC emissions by 1996, with the second and third tiers each requiring an additional 10-percent reduction in emissions by 2000 and 2003, respectively. EPA expects to publish a draft rule, including a 1996 Table of Standards, by November 1, 1993.

Agencies desiring to adopt rules prior to the publication of the draft 1996 Table of Standards (under the regulatory negotiation) may wish to consider adopting the California SCM, at least for the first phase of reductions. The SCM, if applied nationwide, could achieve VOC reductions approaching those expected from the first phase of the regulatory negotiation (i.e., greater than 20 percent). This estimate is conservative, since it does not consider the fact that fewer gallons of low-VOC coatings will be required to cover a given surface area, due to the higher solids content of low-VOC coatings. The limits contained within the SCM are technologically feasible and have been in place in California since 1989.

Table 1 includes the California SCM limits for the various AIM categories.

recent developments in lower-VOC coating technology may allow for standards set lower than California's, producing further emissions reductions.

The Lake Michigan Ozone Control Program predicts that a 250 gram per liter (g/l), less water, limit for flat and nonflat coatings would reduce AIM coating VOC emissions in the Chicago nonattainment area by 2.9 tons per day, or 3.9 percent below the 1990 baseline emissions. Additional reductions could be obtained through the regulation of specialty coating categories. The Chicago nonattainment area currently has no AIM coating regulations.

A study by the New York State Department of Environmental Conservation indicates that, in the New York/New Jersey metropolitan area, a VOC limit of 250 g/l, less water, for both flat and nonflat coatings would reduce emissions by 5.6 tons per day, or 9.3 percent below 1984 baseline emissions.

COST EFFECTIVENESS

To comply with AIM coating limits, manufacturers can replace noncomplying coatings with existing complying coatings or they can reformulate the coatings. Replacement of noncomplying coatings with existing complying coatings is often more cost effective than reformulation because there is minimal research and development involved. Data from a 1984 California marketing survey suggest that the option to replace, rather than to reformulate, noncomplying coatings is available to many coating manufacturers.

The impact on consumers from reformulating coatings can be positive or negative and is difficult to estimate. Some quantifiable factors include the retail cost of the coating, surface coverage per gallon and coating longevity. Other factors, such as increased surface preparation costs, also affect the final cost of the coating, but are difficult to quantify. A CARB technical support document presented the expected economic impacts on consumers in two ways, 1) the expected cost per square foot covered per year for complying coatings compared to noncomplying coatings and 2) the cost-effectiveness of the model rule in dollars per ton of VOC reduced. The cost-effectiveness of the model rule ranged from a credit of \$8,600 per ton of VOCs reduced to a cost of \$12,800 per ton and varied according to the coating category in question.

FEDERAL RULEMAKING AND/OR GUIDANCE DOCUMENTS

Currently, the U.S. Environmental Protection Agency (EPA) is conducting a regulatory negotiation among industry, environmental groups, labor, coating users and

state and local agencies (including STAPPA and ALAPCO) to develop a national rule that reduces VOC emissions from AIM coatings. Consensus on a proposed rule is expected by the end of summer 1993, with a proposal to be published in the Federal Register in late 1993 and a final rule by mid-1994.

❖ *For more information, contact Jim Berry, U.S. Environmental Protection Agency, Emissions Standards Division (MD-13), Research Triangle Park, NC 27711 (telephone: 919/541-5605).*

STATE AND LOCAL CONTROL EFFORTS

The CARB model rule for architectural surface coatings, which was developed in 1977 and revised in 1989, defines and sets VOC content limits for individual categories of AIM coatings. Local district regulations, based upon the model rule, prohibit the use, or manufacture and sale for use, in California of AIM coatings with VOC contents greater than the specified limits. The rule exempts coatings supplied in containers with less than one-liter capacity. In the model rule, the VOC content limit for flat and nonflat coatings was set at 250 g/l, less water, and separate limits were set for each of the specialty categories. The California model rule is included in Table 1. Sixteen of California's 34 local districts have AIM rules in place.

Similar rules are in place for the New York/New Jersey metropolitan area and Maricopa County (Phoenix), Arizona. Texas has an AIM coating rule that regulates on the basis of resin types, rather than coating categories.

REFERENCES

1. U.S. Department of Commerce. Bureau of the Census. October 1991. *Current Industrial Reports: Paint and Allied Products*, 1991, by D.J. Gromos. MA28F(90)-1.
2. California Air Resources Board. July 1989. *ARB-CAPCOA Suggested Control Measure for Architectural Coatings*.
3. Lake Michigan Air Directors Consortium. April 16, 1993. *Control of Emissions from Architectural Surface Coating Draft*.
4. New York State Department of Environmental Conservation. *New York and New Jersey Architectural Surface Coating Study: Phase II Report. Draft*.

Table 1.....
California Suggested Control Measure for Architectural Coatings

Standards:

- (1) No person shall supply, offer for sale, sell, apply or solicit the application of any architectural coating which, at the time of sale or manufacture, contains more than 250 grams of VOCs per liter of coating (less water and exempt solvents and excluding any colorant added to tint bases), or manufacture, blend or repackage such a coating for use.
- (2) No person shall supply, offer for sale, sell, apply or solicit the application of any architectural coating listed in the Table of Standards which contains VOCs (less water and exempt solvents and excluding any colorant added to tint bases), in excess of the corresponding limit specified in the table, after the corresponding date specified, or manufacture, blend or repackage such a coating for use.

Table of Standards

(grams of VOC per liter)

	Effective Dates			
	9/1/84	9/1/89	9/1/92	9/1/94
Below-ground Wood Preservatives	—	600	350	
Bond Breakers	—	50	350 (9/1/90)	
Clear Wood Finishes				
Lacquer	—	680		
Sanding Sealers	—	550	350	
Varnish	500	350		
Concrete Curing Compounds	—	350		
Dry Fog Coatings	—	400		
Fire-retardant Coatings				
Clear	—	650		
Pigmented	—	350		
Form-release Compounds	—	250		
Graphic Arts (Sign) Coatings	—	500		
Industrial Maintenance Coatings	—	420	340	
Industrial Maintenance				
Anti-Graffiti Coatings	—	600	340	
High-temperature Industrial				
Maintenance Coatings	—	650	550	420
Magnesite Cement Coatings	—	600	450	
Mastic Texture Coatings	—	300		
Metallic Pigmented Coatings	—	500		
Multi-color Coatings	—	580	420	
Opaque Stains	400	350		
Opaque Wood Preservatives	400	350		
Pre-treatment Wash Primers	—	780	780	420
Primers Sealers & Undercoaters	400	350		
Roof Coatings	—	300		
Semi-transparent Stains	—	350		
Semi-transparent and Clear				
Wood Preservatives	—	350		
Shellac				
Clear	—	730		
Pigmented	—	550		
Swimming Pool Coatings	—	650	340 (9/1/92)	
Repair and Maintenance Coatings	—	650	340 (9/1/97)	
Traffic Paints				
Public Streets & Highways	415	250		
Other Surfaces	250	250		
Black Traffic Coatings	—	250		
Waterproof Sealers	—	400		

Table 2

Summary Table – Architectural and Industrial Maintenance Coatings

Affected Facilities	Manufacturers and formulators of AIM coatings.
Number of Affected Facilities	Approximately 550 coating manufacturers.
National Emissions Estimates	500,000 tons per year of VOCs from AIM coatings.
Cost Effectiveness	Costs of CARB model rule range from a credit of \$8,600 per ton to a cost of \$12,800 per ton of VOC reduced, depending on category.
Federal Rulemaking and/or Guidance Documents	EPA is conducting a negotiated rulemaking to develop a national rule that reduces VOC emissions from AIM coatings. Consensus on a proposed rule is expected by the end of summer 1993, and a final rule in mid-1994.
State and Local Control Efforts	California, Arizona, New York, New Jersey and Texas have adopted AIM coating regulations.
STAPPA/ALAPCO Recommendation	Adopt the rule resulting from the regulatory negotiation; in the interim, consider adopting the California SCM.

Autobody Refinishing

DESCRIPTION OF SOURCE CATEGORY

Automobile, truck and mobile equipment refinishing coatings are paint products that are applied to various types of vehicles, vehicle parts and components to provide protection and decoration. Auto refinishing coatings are also used for dock repair of imported vehicles and dealer repair of transit damage before the sale of a vehicle. The U.S. Environmental Protection Agency (EPA) makes a distinction between refinishing coatings and coatings applied on the assembly line by the original equipment manufacturer; the latter are covered by EPA under the automobile and light-duty truck Control Techniques Guideline (CTG).

The steps involved in automobile refinishing include surface preparation, surface coating application and equipment cleaning. Emissions from surface preparation (i.e., wipe cleaning) occur due to evaporation of the cleaning solvent from the surface being cleaned. Conventional surface preparation products have average volatile organic compound (VOC) content levels of 6.75 pounds per gallon (lbs/gal) (810 grams per liter) of product.

After surface preparation, a number of surface coatings may be applied, including a pretreatment wash primer or precoat, a primer surfacer, a primer sealer and either sin-

gle-stage, two-stage (basecoat/clearcoat) or three-stage (basecoat/midcoat/clearcoat) topcoats. Table 1 shows the VOC content ranges of automobile refinishing products and the percentage of VOC content that each product contains relative to the overall product category (all limits in this chapter are reported as pounds per gallon of coating, less water and exempt solvents).

Emissions also occur during equipment cleaning. The process, which involves purging the paint from the spray equipment, results in active losses (emissions from actual gun cleaning) and passive losses (emissions that occur when the cleaning system is not in use).

GEOGRAPHIC DISTRIBUTION OF SOURCES

Autobody refinishing shops are located in all fifty states. In 1993, approximately 50,000 autobody refinishing shops were in operation, of which independent operations make up 75 to 80 percent of the business, followed by dealerships (16.5 percent) and franchises (remainder). Autobody shops range in size from small shops with fewer than five employees and sales volume under \$150,000 (40 percent) to volume shops with more than ten employees conducting \$750,000 or more in sales (10 percent). Combined, these

STAPPA/ALAPCO Recommendation

► The three approaches available to reduce VOC emissions from autobody refinishing are to lower the VOC content of the products used, improve the application technique and control the use of clean-up solvents. These three approaches have been implemented in several districts in California (e.g., SCAQMD and BAAQMD).

For application techniques, the use of HVLP spray systems or alternate techniques which achieve 65-percent transfer efficiency have been implemented.

For clean-up solvents, requiring the use of gun-cleaning equipment and proper disposal can be implemented very cost effectively (approximately \$500/ton).

Despite the large number of autobody repair facilities, there are only about six major coating manufacturers. These firms will need to develop reformulated paint to meet limits adopted by state and local agencies.

State and local agencies may wish to adopt the Best Available Retrofit Control Technology (BARCT) limits existing in California. Table 4 summarizes those limits for Group I vehicles (i.e., passenger cars and light- and heavy-duty trucks) and Group II vehicles (i.e., public transit buses and mobile equipment).

shops perform more than \$10 billion in sales annually. The typical refinishing shop employs 5.5 persons, conducts \$344,000 worth of business annually and performs an average of 13 jobs per week.

NATIONAL EMISSIONS ESTIMATES

National VOC emissions estimates for automobile and truck refinishing coatings are provided in Table 2. Dividing the national emissions estimate by the 1990 population of the United States results in a per capita emission factor of 0.86 lb/person per year.

AVAILABLE CONTROL STRATEGIES

The most effective method of reducing VOC emissions from autobody refinishing is to lower the VOC content of the products used. For example, conventional surface preparation products have a VOC content of approximately 6.75 lbs/gal. Surface preparation products with VOC levels below 1.7 lbs/gal are currently available and are reportedly as effective as conventional surface preparation products (although more labor intensive), when the two are used in equal amounts. The South Coast Air Quality Management District (SCAQMD) limits VOC levels in surface preparation products to a maximum of 0.58 lbs/gal of material.

Similarly, top coat and primer applications can reduce emissions by lowering the VOC content of the products used. Waterborne primer surfacers with a VOC content of 2.8 lbs/gal are available and high-solids primers as low as 3.8 lbs/gal are in use. Topcoats have greater operational constraints due to the need to match colors. Coating vendors expect to supply top coating material for the California local air districts, such as the Bay Area Air Quality Management District (BAAQMD), to comply with their 5.0 lbs/gal limit.

Another technique for reducing emissions is to use high transfer efficiency spray equipment, especially high-volume, low-pressure (HVLP) spray systems. The use of HVLP technology in other source categories has been shown to reduce emissions and save money by decreasing coating use, hazardous waste generation and spray booth maintenance costs.

Finally, emissions can also be reduced during the equipment cleaning phase. Equipment can be cleaned either manually, with no control of evaporative solvents, or with gun-cleaning equipment that reduces solvent loss.

POTENTIAL NATIONAL EMISSIONS REDUCTION

Requiring low-VOC surface preparation solvents could reduce VOC emissions by 73 percent.

Use of HVLP technology results in decreased coating usage and a corresponding reduction in emissions. The BAAQMD conservatively estimates that emissions can be reduced 20 to 40 percent by using transfer efficient spray

equipment.

Emission reductions of 88 percent could be achieved by installing gun-cleaning equipment at shops where such systems currently do not exist (41 percent of all shops). This also takes into consideration the emission reduction achieved by proper solvent disposal (recycling or burning as fuel). EPA assumes that 59 percent of all shops nationwide already have automated gun-cleaning systems.

COST EFFECTIVENESS

The cost of reducing the solvent content of surface preparation materials is \$1,250 per ton of VOCs reduced.

The California Air Resources Board estimated the cost effectiveness of the automotive refinishing model rule at \$4,000 to \$4,500 per ton of VOC removed. The SCAQMD estimated the cost effectiveness of meeting Rule 1151 (Motor Vehicle and Mobile Equipment Non-Assembly Line Coating Operations) at \$7,000 per ton of VOC removed. Compliant coatings that are designed to meet new limitations would be more costly on a unit basis; however, the higher solids percentage would extend usage of the product and reduce the amount required for each job. Thus, the costs on a "gallon-of-solids" basis could be equivalent. Additional costs that would be incurred include training costs and loss in shop productivity due to increased drying times for some of the lower-VOC coatings.

The BAAQMD reported that there is actually a cost savings involved in using high-transfer-efficient spray equipment such as HVLP technology. These cost savings can offset additional costs, such as those involved in implementing surface preparation and low-VOC coating technology strategies.

Installation and use of gun-cleaning equipment is expected to cost \$478 per ton of VOCs removed.

FEDERAL RULEMAKING AND/OR GUIDANCE DOCUMENTS

EPA's Emission Standards Division developed a draft CTG for automobile refinishing in 1991. However, to eliminate piecemeal regulation of bodyshops and to avoid the need for enforcement at the body shop level, the agency made a decision in December 1992 to develop a national rule targeting coating manufacturers and suppliers. The national rule is currently under development and will be promulgated under Section 183(e) of the Clean Air Act, relating to commercial and consumer products. Under Section 183(e), EPA's regulations must demonstrate "best available control."

Emissions reductions from coating applications will

be achieved by using low-VOC coatings. EPA obtained information on coatings with low VOC levels through a survey of the major manufacturers of auto refinishing coatings in March 1990. The survey results indicated that all of the major coating manufacturers have developed lower-VOC coatings in order to comply with state regulations. EPA is expected to propose the national rule in mid-1994. To allow companies to deplete existing stocks, compliance with the new rule is not expected to be mandated until the end of 1996. The rule will not cover surface preparation products and gun cleaning.

❖ *For more information on the national rule, contact Mark Morris, U.S. Environmental Protection Agency, Emission Standards Division (MD-13), Research Triangle Park, NC 27711 (telephone: 919/541-5416).*

STATE AND LOCAL CONTROL EFFORTS

Table 3 provides a summary of existing state and local regulations for autobody refinishing.

REFERENCES

1. U.S. Environmental Protection Agency. Office of Air Quality Planning and Standards. *Background Information Document for Automobile Refinishing National Rule*. Draft.
2. Lake Michigan Air Directors Consortium. April 16, 1993. *Evaluation of Possible Control Measures - Control of Emissions from Automobile Refinishing*. Draft.
3. U.S. Environmental Protection Agency. Office of Air Quality Planning and Standards. September 27, 1991. *Automobile Finishing Control Techniques Guideline*. Draft.
4. California Air Resources Board. January 8, 1991. *Determination of Reasonably Available Control Technology and Best Available Retrofit Control Technology for Automotive Refinishing Operations*.

Table 1.....

VOC Ranges of Automotive Refinishing Products

Category	VOC Range (lb/gal) ^a	Average VOC Content (lb/gal) ^a	Percentage Contribution of Product Category
Pretreatment	5.8 - 6.5	6.3	1.2
Precoat	4.6 - 7.1	5.8	0.4
Primer surfacer	4.6 - 7.1	5.7	10.4
Primer sealer	5.0 - 6.7	6.3	5.0
Topcoats	4.6 - 6.7	5.5	55.2
Specialty	7.0	7.0	1.5
Surface Cleaners	6.2 - 7.3	6.75	6.2
Cleanup	6.2 - 7.3	6.75	20.1

^a lb/gal specified in less water and exempt compounds.

Table 2.....

1990 Nationwide Organic Compound Emissions from Automobile and Truck Refinish Coatings^a

Coating Category	Total Volume of Coatings Applied in United States (thousands of gallons)	Average VOC Content (lb/gal)	Emissions (tons/yr)
Primers			
Pretreatment wash primer	610	6.3	1,930
Precoat	200	5.8	580
Primer surfacer	5,280	5.7	15,020
Primer sealer	2,500	6.3	7,990
Topcoats			
Single stage			
Lacquer	2,160	6.3	6,800
Enamel	6,180	5.6	17,330
Basecoat	6,200	6.2	19,230
Clearcoat ^b	13,500	5.2	35,200
Specialty	760	7.0	2,620
Total	37,450	5.7 ^c	106,800

^a Based on information provided to EPA by the National Paint and Coatings Association, Automotive Refinish Coalition. The Automotive Finish Coalition, six of the largest manufacturers of automobile refinishing coatings, have a combined market share of approximately 95 percent.

^b Information provided for clearcoats also includes a very small contribution from midcoats. Information was not provided separately for midcoats.

^c Weighted average VOC content of all coating categories.

Table 3.....

Existing State and Local Autobody Refinishing Regulations

State or Local Area	Applicability	VOC Content Limit ^a
New Jersey	Automobiles, light-duty trucks	Basecoat: 6 lbs/gal Clearcoat: 4.4 lbs/gal Others: 5 lbs/gal
Texas	Automobiles, light-duty trucks	Primers: 2.1 lbs/gal Acrylic enamel: 5.2 lbs/gal Alkyd enamel: 5 lbs/gal Basecoat: 6.2 lbs/gal Clearcoat: 5.2 lbs/gal Lacquer: 6.2 lbs/gal
New York City ^b	Automobiles, trucks, buses	Repair/Touchup: 6.2 lbs/gal Overall (full job): 5 lbs/gal
SCAQMD	Automobiles, light- and medium-duty trucks	Pretreatment: 6.5 lbs/gal Precoat: 5.5 lbs/gal Primer surfacer: 2.1 lbs/gal Primer sealer: 3.5 lbs/gal Topcoats: General: 4 lbs/gal Metallic: 4.3 lbs/gal Multistage: 4.5 lbs/gal Specialty: 7 lbs/gal
	Buses, heavy-duty trucks, mobile equipment	Pretreatment: 6.5 lbs/gal Precoat: 5.5 lbs/gal Other primers: 2.1 lbs/gal Topcoats: General: 2.8 lbs/gal Metallic: 3.5 lbs/gal Multistage: 3.5 lbs/gal Specialty: 7 lbs/gal
BAAQMD	Automobiles, trucks	Pretreatment: 6.5 lbs/gal Precoat: 6.5 lbs/gal Primer surfacer: 2.8 lbs/gal Primer sealer: 3.5 lbs/gal Topcoat: 5.0 lbs/gal
	Public transit buses, mobile equipment	Pretreatment: 6.5 lbs/gal Precoat: 6.5 lbs/gal Other primers: 2.8 lbs/gal Topcoat: 3.5 lbs/gal
California Air Resources Board ^c	Automobiles, trucks	Pretreatment: 6.5 lbs/gal Precoat: 6.5 lbs/gal Primer surfacer: 2.8 lbs/gal Primer sealer: 3.5 lbs/gal Topcoat: 5.0 lbs/gal Specialty: 7 lbs/gal
	Public transit buses, mobile equipment	Pretreatment: 6.5 lbs/gal Precoat: 6.5 lbs/gal Other primers: 2.8 lbs/gal Topcoat: 3.5 lbs/gal Specialty: 7 lbs/gal

^a Less water and exempt compounds.

^b The New York rule will also cover upstate sources with emissions greater than 50 tpy beginning in 1995.

^c This is a guideline, not a rule.

Table 4

RACT and BARCT Standards for Automotive Refinishing Operations

Standards for Group I Vehicles

	RACT	BARCT	
	Effective Date ^a VOC (lbs/gal)	1/1/92 VOC (lbs/gal)	1/1/95 VOC (lbs/gal)
Pretreatment Wash Primer	780 g/l (6.5)	780 g/l (6.5)	420 g/l (3.5)
Precoat	780 g/l (6.5)	780 g/l (6.5)	420 g/l (3.5)
Primer/Primer Surface	720 g/l (6.0)	340 g/l (2.8)	250 g/l (2.1)
Primer Sealer	720 g/l (6.0)	420 g/l (3.5)	340 g/l (2.8)
Topcoat	720 g/l (6.0)	600 g/l (5.0)	460 g/l (3.8)
Metallic/Iridescent Topcoat	720 g/l (6.0)	600 g/l (5.0)	540 g/l (4.5)
Specialty Coating	840 g/l (7.0)	840 g/l (7.0)	840 g/l (7.0)

Standards for Group II Vehicles and Mobile Equipment

	RACT	BARCT	
	Effective Date ^a VOC (lbs/gal)	1/1/92 VOC (lbs/gal)	1/1/95 VOC (lbs/gal)
Pretreatment Wash Primer	780 g/l (6.5)	780 g/l (6.5)	420 g/l (3.5)
Precoat	780 g/l (6.5)	780 g/l (6.5)	420 g/l (3.5)
Primer	340 g/l (2.8)	340 g/l (2.8)	250 g/l (2.1)
Topcoat	420 g/l (3.5)	420 g/l (3.5)	340 g/l (2.8)
Metallic/Iridescent Topcoat	650 g/l (5.4)	420 g/l (3.5)	420 g/l (3.5)
Extreme Performance	750 g/l (6.2)	750 g/l (6.2)	420 g/l (3.5)
Camouflage	420 g/l (3.5)	420 g/l (3.5)	420 g/l (3.5)
Specialty Coating	840 g/l (7.0)	840 g/l (7.0)	840 g/l (7.0)

^a Effective date is six months after date of adoption.

Control Requirement: VOC limits for coatings used in Group I or II or mobile equipment above can be waived provided an add-on control device that achieves a maximum capture efficiency using EPA protocols and at least 85-percent destruction efficiency is installed and operated. In addition, the overall efficiency of the system shall be at least as effective in emission reductions as the level of control of complying coatings.

Summary of Common Requirements for Both RACT and BARCT

Other Standards Requirements

- **Lacquer Spot/Panel Repair Standards:** Less stringent VOC limits for lacquer coatings applied on Group I vehicles until 12 months after the date of adoption.
- **Transfer Efficiency:** Electrostatic application, HVLP spray equipment and other equipment that achieves at least 65-percent transfer efficiency.
- **Surface Preparation and Clean-up Solvent:** VOC limit of 200 g/l (1.67 lbs/gal) for surface preparation and other clean-up practices.
- **Specialty Coatings:** No more than 5 percent of all coatings used.

Exemptions

- **Vehicle or Mobile Equipment:** Original equipment manufacturer coatings applied at manufacturing or assembly plants.

Administrative Requirements

- **Coating and Solvent Records:** Maintain coating records on a daily basis and on a monthly basis for solvents used for clean-up and surface preparation.

Test Methods

- **Analysis of Samples:** EPA Reference Method 24 or equivalent.
- **Determination of Emissions:** EPA Reference Method 25 or Equivalent.
- **Determination of Transfer Efficiency:** Method approved by the Executive Office.
- **Determination of Capture Efficiency:** EPA guidelines.
- **Determination of Iridescent Particles in Metallic/Iridescent Topcoat:** SCAQMD Spectrographic Method 26.
- **Determination of Acid Concentration in Pretreatment Wash Primer:** ASTM D-1613-85 (modified).

Table 5

Summary Table – Autobody Refinishing

Affected Facilities	Autobody repair shops and automobile dealerships. Manufacturers and distributors of autobody refinishing coatings.			
Number of Affected Facilities	50,000 repair shops and dealerships would be affected by a national rule. Six major coating manufacturers accounting for 95 percent of the market would also be affected.			
National Emissions Estimates	National VOC emissions estimates were 106,800 tons/year in 1990.			
VOC Emissions Range Per Facility	Number of Shops	Small 33,200	Medium 41,300	Large 8,600
	Pounds/Day/Shop	3.8	29	89
100 TPY Source Size	None; large sources emit approximately 11.6 tpy.			
Potential Emissions Reduction Per Facility	Option I: 43 percent for sources located outside areas with existing regulations. Option II: 45 percent for sources located outside areas with existing regulations.			
Cost Effectiveness	Surface preparation: \$1,250/ton. Surface coating: \$4,000 to \$4,500/ton. Gun-cleaning equipment: \$478/ton.			
Federal Rulemaking and/or Guidance Documents	EPA is currently developing a national rule for autobody refinishing, with proposal expected in mid-1994. To allow producers to deplete their stocks, compliance is not expected to be required until the end of 1996.			
State and Local Control Efforts	See Table 3.			
STAPPA/ALAPCO Recommendation	Require HVLP spray systems and gun-cleaning equipment for clean-up solvents and consider adopting BARCT limits existing in California.			

Automobile Assembly

DESCRIPTION OF SOURCE CATEGORY

Automobile assembly is a multi-step operation carried out on a conveyor system known as an assembly line. Lines operate at 9 to 25 feet per minute and generally produce 30 to 70 units per hour. An automobile assembly plant may operate up to three eight-hour shifts per day. Plants usually halt production for several weeks during the summer season for inventory and model changeover. Although assembly processes vary from plant to plant, there are some common characteristics.

The major volatile organic compound (VOC) emissions from an assembly process are from the surface coating of the vehicle. The major steps of the surface coating process are the following:

- Organic solvent wipe;
- Phosphating treatment;
- Application of the primer coat;
- Curing of the primer coat;
- Application of the guide coat;
- Curing of the guide coat;
- Application of the topcoat(s);

- Curing of the topcoat(s); and
- Paint touch-up operations.

Other VOC emissions at automobile assembly plants result from the application of sealers, adhesives, body and glass primers, body-wipe solvents, wheel topcoat coatings, antirust coatings, trunk coatings, interior coatings, flexible coatings, plastic parts, accent and stripe coatings, glass cleaners and line purge and booth cleaning solvents, as well as the use of floor cleaners, cutting oils from machining operations and automobile fascia painting. Of the sources listed above, Reasonably Available Control Technology (RACT) limits have been established only for coating and curing (including flash-off) operations.

GEOGRAPHIC DISTRIBUTION OF SOURCES

In 1992, 43 automobile and light-duty truck assembly plants were located in 41 cities in 18 states. In 1989, approximately 32 percent of the 6.8 million automobiles produced in the United States were manufactured in Michigan.

STAPPA/ALAPCO Recommendation

► State and local agencies should consider requiring spray booth abatement, which has been demonstrated to achieve levels of 5.8 lbs/gal, solids applied. Agencies have made BACT determinations, without spray booth abatement, at 10 lbs/gal, solids applied.

NATIONAL EMISSIONS ESTIMATES

Surface-coating operations generate the largest volume of VOC emissions in an automobile assembly operation. According to the U.S. Environmental Protection Agency (EPA), the average use of coating for automobile surface-coating operations has been estimated to be 14.0 liters (3.7 gal) per car using a solvent-based primer, and 9.9 liters (2.6 gal) per car using an electrodeposition primer, guide coat and topcoat. Based on the per car averages above, national VOC emissions for 1989 ranged from 70,700 tons per year (tpy) to 100,600 tpy.

AVAILABLE CONTROL STRATEGIES

Several types of control techniques are used in the automobile and light-duty truck manufacturing industry. These methods can be broadly categorized as either add-on control devices or new coatings application systems. Add-on devices that reduce emissions by recovering or destroying the solvents before they are discharged into the ambient air include thermal and catalytic incinerators and carbon adsorbers.

New coatings can be considered control methods when they contain relatively low levels of solvents in place of a high-solvent content. Such methods include electrodeposition of water-based primer and air or electrostatic spray of water-based coatings and powder coatings. Because of the lower solvent content of the new coating, these application methods are inherently less polluting than processes that use conventional solvent-based coatings.

High transfer efficiency systems are also used to minimize coating usage.

POTENTIAL NATIONAL EMISSIONS REDUCTION

Since cleanup solvents and sealers are not regulated in most areas, reformulation of these materials may provide the potential for additional reductions. In addition, reconfigured automobile assembly plants will most likely be subject to Best Available Control Technology (BACT) or Lowest Achievable Emission Rate (LAER) if a construction permit is required.

FEDERAL RULEMAKING AND/OR GUIDANCE DOCUMENTS

EPA published a Control Techniques Guideline (CTG) for the automobile industry in May 1977 that recommended the following limits (lbs per gallon of coating less water):

Prime application, flashoff area and oven	1.9
Topcoat application, flashoff area and oven	2.8
Final repair application, flashoff area and oven	4.8

In 1980, EPA promulgated a New Source Performance Standard (NSPS) (40 CFR 60.390, Subpart MM) for the industry with the following limitations (lbs per gallon of applied solids):

Prime coat operation	1.3
Guide coat operation	11.6
Top coat operation	12.1

A National Emission Standard for Hazardous Air Pollutants (NESHAP) for the industry is due by November 1997; however, no work is currently underway.

EPA developed a document entitled, *Protocol for Determining the Daily Volatile Organic Compound Emission Rate of Automobile and Light-Duty Truck Topcoat Operations* (June 10, 1988), which addresses the recordkeeping requirements needed to comply with RACT. The issues addressed in the document are pertinent to all reviews (e.g., transfer efficiency, VOC content of coatings, flash/curing oven split).

STATE AND LOCAL CONTROL EFFORTS

Eighteen states have VOC regulations in place for automobile assembly surface coating; most of these meet RACT requirements.

Wisconsin's RACT requirements for automobiles or light-duty trucks are typical:

- 1.2 lb VOC/gallon coating, excluding water, from an electrodeposition prime coat or equivalent;

- 2.8 lb VOC/gallon coating, excluding water, from a spray primer-surfacer;
- 2.8 lb VOC/gallon coating, excluding water, from a topcoat line; and
- 4.8 lb VOC/gallon coating, excluding water, from a final repair coating line.

Examples of state and local agencies with regulations that go beyond RACT include Georgia and the South Coast Air Quality Management District (SCAQMD). Georgia has promulgated the following limits for several non-CTG VOC sources:

Low-use sealers	3.5 lb VOC/gal
High-use sealers	1.0 lb VOC/gal
Adhesives	3.5 lb VOC/gal
Body glass cleaner	6.9 lb VOC/gal
Body glass primer	5.5 lb VOC/gal
Other adhesive/sealer	3.5 lb VOC/gal
Fascia basecoat	4.4 lb VOC/gal
Fascia clearcoat	4.4 lb VOC/gal

A rule effectiveness study conducted by Georgia for plants located in Atlanta concluded that three facilities examined were in compliance with the daily allowable VOC emission limits.

SCAQMD Rule 1115, "Motor Vehicle Assembly Line Coating Operations," was originally adopted March 2, 1979 to reduce emissions from coatings applied to vehicles during assembly line operations. The South Coast Air Basin currently has only one facility with operations that are covered under Rule 1115. The control efforts in this rule focus on reducing the VOC content of the coating and increasing the transfer efficiency of the application. The rule also allows an alternative emissions control plan to be filed. Coating operations not associated with applying body primer and topcoat coatings to exterior sheet metal and body are not subject to the VOC limits in this rule. In addition, the following coatings are exempt from the VOC requirements: wheel topcoat coatings, antirust coatings, trunk coatings, interior coatings, flexible coatings, sealers and deadeners, plastic parts and accent and stripe coatings.

The emissions from the clean-up of coating application equipment have been regulated since July 1, 1992 by SCAQMD Rule 1171, "Solvent Cleaning Operations." This rule addresses cleaning and surface preparation, repair and maintenance cleaning and application equipment cleaning. The control efforts limit the VOC content and the vapor pressure of the solvents used in these categories. In addition, the rule specifies the method and/or equipment to be used for these operations.

In Illinois, the emissions limit for automobile and light-duty truck coating is 1.2 lbs volatile organic material (VOM)/gal of prime coat and 2.8 lbs VOM/gal of prime surfacercoat. Non-CTG sources are regulated under a set of generic rules based upon the Chicago Federal Implementation Plan, in general.

REFERENCES

1. U.S. Environmental Protection Agency. May 1977. *Control of Volatile Organic Compounds Emissions from Existing Stationary Sources, Volume II: Surface Coating of Cans, Coils, Paper, Fabrics, Automobiles, and Light-Duty Trucks*. EPA-450/2-77-008.
2. Data Gathered by Pacific Environmental Services to Develop NESHAP Standard for the Automobile and Light-duty Truck Manufacturing Industry. August 1992. EPA Contract 68D10116, Work Assignment No. 20.
3. U.S. Environmental Protection Agency. September 1979. *Automobile and Light-Duty Truck Surface Coating Operations - Background Information for Proposed Standards*. EPA-450/3-79-030.
4. Georgia Department of Natural Resources. July 1993. *Summary of Non-CTG VOC RACT Control Measures*.
5. U.S. Environmental Protection Agency. November 2, 1992. *Rule Effectiveness Study of Georgia's Rule (t): VOC Emissions from Automobile and Light-Duty Truck Manufacturing*. EPA Contract No. 68-02-4462, Work Assignment 89-86.

Table 1.....**Summary Table – Automobile Assembly**

Affected Facilities	New and existing automobile assembly plants.
Number of Affected Facilities	43 facilities in 1991.
National Emissions Estimates	70,700 to 100,600 tpy of VOCs.
100 TPY Source Size	Every facility is a major 100 tpy source.
Federal Rulemaking and/or Guidance Documents	CTG published May 1977. NSPS promulgated December 1980. Protocol for VOC emission calculations published June 1988. NESHAP due November 1997
State and Local Control Efforts	Eighteen states have promulgated surface coating regulations. Georgia has promulgated rules for non-CTG sources, including automobile assembly plants. SCAQMD has promulgated rules for automobile assembly coating operations and for cleanup solvents, including those used at automobile assembly plants.
STAPPA/ALAPCO Recommendation	Consider requiring spray booth abatement at 5.8 lbs/gal, solids applied; without spray booth abatement, a 10-lbs/gal level is achievable.

Bakeries

DESCRIPTION OF SOURCE CATEGORY

Volatile organic compound (VOC) emissions from bakery ovens result from the use of yeast cells to leaven dough. The term bakery applies to a facility that produces bread, rolls, buns and similar yeast-leavened products; it does not include facilities that produce crackers, tortillas, pretzels, sweet goods or baked foodstuffs that are not yeast-leavened. A large bakery may produce up to 300,000 pounds of bread and other bakery products each day.

VOCs are the primary air pollutants emitted from bread bakeries. The anaerobic biological activity of yeast used to leaven bread dough produces ethanol, carbon dioxide, glycerol, organic acids, aldehydes and minor amounts of other compounds. Typically, yeast fermentation of 100 pounds of sugar produces 47 pounds of CO₂, 40 pounds of ethanol and 4 pounds of glycerol, organic acids and other minor compounds. Emissions from the production of baker's yeast are not included in this source category. At least 90 percent of VOC emissions from bakeries are emitted from the baking ovens.

GEOGRAPHIC DISTRIBUTION OF SOURCES

In 1990 there were over 2,600 commercial bakeries in the United States. The baking industry is decentralized because bread is a perishable commodity. Bakeries tend to be located near large population centers, particularly along the east and west coasts and in the midwest, to minimize distribution time.

NATIONAL EMISSIONS ESTIMATES

While national estimates of VOC emissions from bread bakeries are difficult to assess, it is anticipated that emissions will increase by 2.2 percent per year to match increasing consumption of bread products.

It is possible to predict total VOC emissions from common baking operations through the generation of mathematical equations. The most recently developed equation states that:

$$\text{VOC E.F.} = 0.95 Y_i + 0.195 t_i - 0.51 S - 0.86 t_s + 1.90$$

where:

VOC E.F. = pounds of VOC per ton of baked bread

Y_i = initial baker's percent of yeast, to the nearest tenth of a percent

t_i = total yeast action time in hours, to the nearest tenth of an hour

S = final (spike) baker's percent of yeast, to the nearest tenth of a percent

t_s = spiking time in hours, to the nearest tenth of an hour

Note: The term "baker's percent" is unique to the baking industry. The baker's percent of an ingredient in a bread formula refers to the weight of that ingredient per 100 pounds of flour in the formula. For a given formula, the baker's percent of all the ingredients will total more than 100 percent, as the flour alone equals 100 baker's percent.

This equation can be used to quantify regionwide VOC emissions from bakery ovens for loaf bread, but should not be applied to individual bakeries. The variables in the equation are well understood by the baker and are a normal part of production recipes. Annual VOC emissions can be calculated for each oven in a bakery if the recipes for bread dough are available and if the annual production of each type of bread baked in each oven is known or can be estimated. The following equation can be used to calculate annual VOC emissions for a single type of bread from a bread baking oven:

$$\text{Tons/Year VOC Emissions} = (\text{VOC E.F.}) (\text{BP}) (k)$$

where:

VOC E.F. = pounds VOC emissions/tons of bread produced

BP = bread production in tons/yr

k = conversion constant (ton/2,000 lbs)

The total annual VOC emissions from a particular bread oven in a bakery can be calculated by performing the above calculation for each bread formula used in the oven and adding the amounts obtained.

AVAILABLE CONTROL STRATEGIES

Typical available control strategies are grouped into two categories: combustion and noncombustion control devices. Combustion devices include thermal incineration, catalytic incineration and regenerative thermal oxidation. Noncombustion control devices include scrubbing, condensation, carbon adsorption and biofiltration. All twenty-three of the production bread baking ovens that currently have controls for VOC emissions use combustion devices; twenty-one use catalytic incineration, one uses

thermal incineration and one uses regenerative incineration. Process and formulation changes currently being investigated could also provide VOC control.

Combustion Devices: The first bread-baking oven believed to have VOC emissions controls uses a catalytic incinerator and is located in San Francisco, California. Emission tests from this incinerator indicated that a combustion temperature as low as 600°F would still permit a destruction efficiency of 98 percent or greater. Anticipated problems related to suspended droplets of fats and oils in the exhaust gases did not materialize.

Thermal incinerators appear capable of achieving a destruction efficiency equal to that of catalytic incinerators. However, without the catalyst bed to enhance oxidation, they must operate at a higher combustion temperature, thus using more fuel and contributing to higher operating costs.

Regenerative oxidation involves the use of a thermal incinerator with very high heat recovery. A fixed- or moving-bed regenerative system provides heat recovery by heating a medium with the incinerator exhaust gases, then reversing air flow through the same medium to recover the stored thermal energy. The cost effectiveness of regenerative incineration, compared to thermal or catalytic incineration, must be evaluated for each installation. Variables favorable to the selection of regeneration incinerators include high fuel costs, long operating periods and low interest rates.

Noncombustion Devices: The chemical and physical characteristics of ethanol (the primary VOC in bread oven exhaust gases) limit the effectiveness of noncombustion control devices.

Scrubbing (absorber) systems are designed to maximize the surface interface of the gas stream with a liquid solvent, usually water. Ethanol has a high affinity to water and is easily absorbed into water from the gas stream. However, this affinity makes removal and recovery of ethanol from the water difficult and expensive. If a facility discharges ethanol-laden water into public sewers, it generally must pay additional sewer charges for the increased biological oxygen demand levels.

Condensation also poses problems. The relative humidity inside baking ovens is high due to the water vapor that migrates out of bread products. In order to condense VOCs from baking oven emissions, this water vapor must first be condensed; freon cooling can then be used to remove the ethanol condensate. The effectiveness of condensation is reduced by water freezing on cooling coils and fats and oils becoming deposited in ductwork, creating sanitation problems. Fats and oil vapors will also condense, creating additional disposal problems.

Adsorption of ethanol on carbon beds, although technically possible, is made difficult by the high temperature and high relative humidity of bread oven exhaust. Carbon adsorption efficiency decreases with increasing temperature and humidity. Adsorption on carbon beds can be 95-percent effective; however, fats and oils can reduce the effectiveness by clogging carbon pores. In addition, ethanol's affinity for charcoal is strong enough to prevent the complete removal of ethanol from the carbon bed during steam regeneration, lowering carbon bed adsorption capacity. Moreover, ethanol combines with steam used during regeneration to form condensate, which may become a disposal problem.

POTENTIAL NATIONAL EMISSIONS REDUCTION

Potential national emissions reduction will depend upon the control measures required. The maximum control efficiency for a bakery plant is expected to approach 88 percent, with 10 percent of total emissions released outside of the bread baking ovens as fugitive VOC emissions. If only process VOC emissions from bread baking ovens are considered (90 percent of total bakery emissions), then an estimated 98-percent maximum destructive efficiency can be expected. Bread baking ovens are usually fully enclosed and are operated with a slight negative pressure. These features assist in the collection of virtually all of the VOCs released in the ovens. However, fluctuation in oven temperatures, variations in oven product loading and normal deterioration of catalytic bed materials all work to reduce overall control of emissions.

COST EFFECTIVENESS

Cost effectiveness of controlling VOC emissions from bread-baking ovens improves as production rates and operating hours increase. Calculations for catalytic incineration demonstrate a cost-effectiveness range of between \$700/ton of VOCs reduced for baking ovens with 10 million British thermal units (MM Btu) heat input to slightly less than \$3,000/ton for small bread baking ovens with approximately 2 MM Btu heat input. For catalytic oxidation of VOC emissions, control costs equate to a range of \$0.0012 to \$0.0031 per pound of bread produced (1991 dollars).

FEDERAL RULEMAKING AND/OR GUIDANCE DOCUMENTS

In 1992, EPA issued an Alternative Control Technology document for bakery oven emissions. In addition, locations subject to New Source Review regulations typically

STAPPA/ALAPCO Recommendation

► Devices are available to control ethanol emissions from baking ovens by at least 95 percent. Since emissions vary significantly by bread baking formula, exemptions based on lower emission rates (e.g., 50-150 lbs of ethanol per day) or smaller commercial bakeries (e.g., 50,000 lbs of baked goods per day, 2 MM Btu heat input) may be appropriate.

review increases of 40 tons per year or greater in nonattainment areas. EPA also is developing guidance on how to determine what constitutes a significant emissions increase in areas classified as Serious, Severe, or Extreme for ozone.

Areas attaining the national ambient air quality standards and subject to Prevention of Significant Deterioration (PSD) regulations typically evaluate significant increases in VOC emissions from an existing or new bakery if either is a PSD source.

STATE AND LOCAL CONTROL EFFORTS

Several local air pollution control districts in California have adopted regulations to control ethanol emissions from large commercial bakeries.

The South Coast Air Quality Management District (SCAQMD) adopted Rule 1153, "Commercial Bakery Ovens," on January 4, 1991, to control VOC emissions from bakery ovens. The rule specifies emissions reductions for existing ovens (those installed prior to January 1, 1991) and new ovens (those installed on or after January 1, 1991). All ovens rated at less than 2 MM BTU per hour or emitting less than 50 pounds of VOC per day are exempt from the rule. Existing ovens emitting between 50 and 100 pounds per day were required to reduce their emissions by 70 percent (by weight) by July 1, 1993. Existing ovens emitting 100 pounds per day or more are required to reduce their emissions by 95 percent (by weight) by July 1, 1994. New ovens must be fitted with control equipment that will reduce emissions by at least 95 percent by weight. SCAQMD requires EPA Test Method 25 or SCAQMD Test Method 25.1 to be followed when measuring emissions.

In 1989, the Bay Area Air Quality Management District (BAAQMD) adopted Regulation 8, Rule 42; the regulation became effective on January 1, 1992. This rule requires a 90-percent reduction in ethanol emissions from large commercial bakeries. Emissions are estimated using the American Institute of Bakeries formula and measured using the BAAQMD Method ST-32. The rule exempts bakeries producing less than 100,000 pounds per day of bread, averaged monthly, and ovens emitting less than 150 pounds per day of ethanol. Ovens in operation prior to January 1, 1988 are exempt from the regulation if they emit no more than 250 pounds per day of ethanol.

The San Diego County Air Pollution Control District has published a tactic evaluation that requires a 90-percent reduction in emissions of reactive organic gases (ROG) from large commercial bakeries. This document projects a 90-percent control efficiency and a cost effectiveness of \$6,280 using catalytic incineration. Full implementation would be realized in the fifth year.

Areas outside California have regulated bakeries, as well. New Jersey limits VOC emissions to between 3.5 and 15 pounds per hour. In Washington, the Puget Sound Air

Pollution Control Agency limits ethanol emissions to levels that will not cause ambient concentrations to exceed 6,000 micrograms per cubic meter (mg/m^3). Ambient modeling is used to demonstrate compliance. North Carolina limits acetaldehyde emissions to levels that will not cause ambient concentrations greater than $27 \text{ mg}/\text{m}^3$.

REFERENCES

1. U.S. Environmental Protection Agency. Office of Air Quality Planning and Standards. December 1992. *Alternative Control Technology Document for Bakery Oven Emissions*. EPA-453/R-92-017).
2. American Institute of Baking. December 1987. *Bakery Oven Ethanol Emissions - Experimental and Plant Survey Results*. Volume IX, Issue 12.
3. South Coast Air Quality Management District. *Staff Report for Rule 1153*.

BAKERIES

Table 1.....
Summary Table – Bakeries

Affected Facilities	Bakeries using yeast to leaven bread and bread products.			
Number of Affected Facilities	2,636 potentially affected facilities, assuming no exemptions.			
VOC Emissions Range Per Facility	SIZE OF OVEN	Small	Medium	Large
	Btu/hr heat input	3x10 ⁶	5x10 ⁶	10x10 ⁶
	Average emissions (tons/year)	23	39	78
100 TPY Source Size	Bread baking ovens with 10x10 ⁶ Btu/hr heat input and a VOC emission factor of 6.9 lbs per ton of bread baked.			
Potential National Emissions Reduction	Bakeries are capable of maintaining a 95-percent destruction and control efficiency.			
Cost Effectiveness	Calculated cost effectiveness for catalytic incineration is between \$700/ton VOC for baking ovens with 10 MM Btu heat input, to slightly less than \$3,000/ton for small bread baking ovens with approximately 2 MM Btu heat input.			
Federal Rulemaking and/or Guidance Documents	EPA published an ACT document for bakery oven emissions in December 1992. A guidance document on determining what constitutes a significant emissions increase in areas classified as Serious, Severe or Extreme for ozone is being developed.			
State and Local Control Efforts	<p>SCAQMD and BAAQMD have adopted VOC regulations for bread bakeries. SCAQMD calls for control of ethanol for ovens with ethanol emissions greater than 50 lbs/day. BAAQMD exempts ovens producing less than 100,000 lbs of bread per day or emitting less than 150 lbs of ethanol per day.</p> <p>San Diego has published a tactic evaluation for bakeries requiring ROG emissions to be reduced by 90 percent, with a calculated cost effectiveness of \$3.14 or \$3.45 per pound.</p> <p>New Jersey limits VOC emissions to between 3.5 and 15 pounds per hour.</p> <p>The Puget Sound Air Pollution Control Agency limits ethanol emissions to levels that will not cause ambient concentrations to exceed 6,000 mg/m³. Ambient modeling is used to demonstrate compliance.</p> <p>North Carolina limits acetaldehyde emissions to levels that will not cause ambient concentrations greater than 27 mg/m³.</p>			
STAPPA/ALAPCO Recommendation	Control ethanol emissions from baking ovens by at least 95 percent; consider exemptions based on lower emissions rates (e.g., 50-150 lbs of ethanol per day) or smaller commercial bakeries (e.g., 50,000 lbs of baked goods per day, 2 MM Btu heat input).			

Batch Processes

DESCRIPTION OF SOURCE CATEGORY

The term batch process refers to sets of unit operations used on a noncontinuous basis to manufacture products. Although batch processes often have common unit operations, the unit configurations can be almost infinite. Typical unit operations include reaction, filtration, extraction, distillation, crystallization, drying, storing and shipping. Batch processes are used in manufacturing polymers (resins), pharmaceutical products, pesticides, and synthetic organic chemicals.

All four of these industries would be affected by the U.S. Environmental Protection Agency's (EPA's) draft Control Techniques Guideline (CTG) for batch processes. Other industries that would be affected by the CTG are gum and wood chemicals, medicinal and botanical products and cyclic crudes and intermediates.

GEOGRAPHIC DISTRIBUTION OF SOURCES

Batch processes are common throughout the United States, with some concentrations in the northeast, the Ohio River Valley, the Gulf Coast and the far west. EPA's draft CTG does not identify specific companies engaged in batch processes or their locations.

NATIONAL EMISSIONS ESTIMATES

Because of the nature and diversity of this industrial category, the EPA draft CTG makes several simplifying assumptions to determine annual national emissions. The guidance assumes that the model processes described in the document are evenly used among the industries covered, and that low, moderate and high volatility materials are used in equal amounts nationwide. Emission estimates for small-, medium-, and large-sized plants in nonattainment areas were obtained by multiplying the census size groupings (the number of employees per plant) by model plant emission totals. Only those facilities located in nonattainment areas (excluding Marginal nonattainment areas) were considered. Based on these assumptions, EPA estimates national annual VOC emissions at 77,000 Megagrams per year (Mg/yr).

AVAILABLE CONTROL STRATEGIES

Control techniques available for batch processing are condensation (water or refrigerated), absorption, adsorption, oxidation (flares and thermal or catalytic incinerators) and vapor containment. Because of the intermittent nature of flows in batch processing, control techniques should be

capable of effectively processing emissions from both peak periods and no-flow periods.

Condensers: These are usually divided into two types: direct contact and non-contact condensers. Direct contact condensers spray a cooled liquid directly into the emission stream. This contact is made in either a packed or unpacked vessel or tower. Liquid separators are usually required to separate the cooling medium from the condensate. An exception is when the cooling medium used is the same material as the condensate.

Noncontact condensers incorporate a physical barrier between the cooling medium and the gases to be condensed. The best known example of a noncontact condenser is a shell and tube heat exchanger. Hot gases pass through the inside of the tubes, are cooled and then condense. The cooling medium is circulated on the shell side and never directly contacts the condensate.

Condensers are used most extensively on rich-vapor streams, such as reactor vents. Depending on the application and the volatility of the materials, the cooling medium could consist of anything from ambient temperature water to highly refrigerated brine solution. Direct contact condensation is not typically used because of its low efficiency and the high cost of waste disposal.

Absorbers: These units provide an environment for intimate contact between a gas stream containing a soluble material and a contacting liquid. They are often referred to as "scrubbers" and come in a number of different configurations. The most frequently used are packed towers and spray chambers. The lower the actual volatile organic compound (VOC) concentration in the liquid (the further the VOC concentration is from the liquid equilibrium concentration), the more rapidly the VOC will transfer from the gas to the liquid media.

Scrubbers are often used as secondary control devices on the outlet vent of condensers. An evaluation of whether to use a scrubber in a given application should be based on its ability to remove and treat VOCs from scrubbing media.

Carbon Adsorbers: These devices capture VOC material from a gas phase on a granular surface of activated carbon. There are two basic types of carbon adsorbers: fixed-bed and fluidized-bed. In fixed-bed adsorbers, the VOC-laden gas is passed through a fixed bed of granules of activated carbon. The activated carbon has an affinity for the VOCs; as long as the VOC concentration on the carbon is less than the equilibrium concentration, VOCs will move from the gas stream to the carbon. When the carbon bed reaches equilibrium, "breakthrough" occurs; at this point, it is necessary to shut down the unit, switch the gas flow to a standby unit and regenerate the first unit by driving off the VOCs. Emissions from the regenerating unit can be

condensed, flared or otherwise oxidized.

In fluidized-bed adsorbers, activated carbon granules are fluidized by the gases being cleaned. In a constant process, carbon is removed from the bed, screened, regenerated and added back to the system along with make-up carbon. Vapors from the regeneration must be destroyed or condensed and recycled. Due to cost considerations, the fixed-bed design is usually preferred in all but the very largest units.

Carbon adsorbers are often used as collectors or concentrators of VOCs, especially in low-VOC concentration streams. By concentrating the VOC content, these units can greatly reduce the size of gas stream incinerators. This, in turn, significantly reduces capital and operating costs.

Oxidation: Oxidation is the most frequently used control technique for VOC destruction. VOCs heated to the autoignition temperature in the presence of sufficient oxygen will oxidize to form carbon dioxide and water. Autoignition temperatures differ from chemical to chemical. The higher this temperature, the more expensive it is to destroy the compound. Another important consideration is the residence time at the autoignition temperature; the longer the residence time, the more complete the destruction. Adequate mixing with the combustion air is also necessary to ensure complete oxidation.

Oxidation can be achieved through the use of flares, thermal incinerators or catalytic incinerators. Each technology has advantages and disadvantages.

- The use of flares involves collecting and routing process vent emissions to a main stack through a collection header. A knock-out drum is often incorporated in the header to remove water and condensed organics. Pilot burners are used for ignition. Flares perform best on a waste gas stream of high heating value and uniform flow. The destruction efficiency is affected by the autoignition temperature of the gas and reactivity (i.e., temperature and residence time). Flares are not widely used in batch processing because they operate more efficiently under continuous flow conditions.
- A thermal incinerator is a refractory-lined chamber containing burners at one end. The gas waste stream and the combustion products are thoroughly mixed in the chamber. The chamber is designed to provide the gases a residence time of 0.3 to 1.0 seconds while in the incinerator chamber. The incinerator off-gases leave the chamber at or slightly under the autoignition temperature. For improved operating economics, the off-gases

STAPPA/ALAPCO Recommendation

► State and local agencies should consider setting limits of 98-percent control efficiency, as achieved by current technologies (e.g., catalytic oxidizers).

Exemptions should be provided for emission streams from individual units based on considerations of volatility, annual emissions and flow rate. For a given level of annual emissions, units with a flow rate lower than that derived from the cutoff equations shown below should be controlled to 98 percent (flow rate expressed in terms of SCFM and Annual Emissions in lbs/year):

Volatility	Equation
Low (less than 75 millimeters of mercury [mm Hg])	$FR = (.052) AE - 789$
Medium (75 to 150 mm Hg)	$FR = (.018) AE - 290$
High (greater than 150 mm Hg)	$FR = (.015) AE - 256$

In addition, individual units that emit less than 500 lbs/year should be exempted.

are often used to preheat the incoming waste gas stream. However, to prevent the possibility of explosion when incoming gases are preheated, insurance companies require the VOC concentration in the waste to be less than 25 percent of the lower explosive limit. Tests have shown 98-percent destruction efficiency for most VOC compounds at combustion chamber temperatures between 700°C and 1,300°C (1,380°F to 2,370°F) and residence times of 0.5 to 1.5 seconds.

■ The main advantage of catalytic incinerators is that they operate at much lower temperatures than thermal oxidizers, due to the use of catalysts that cause VOCs to react with oxygen at lower temperatures than in thermal units. Reduced operating temperatures greatly reduce fuel consumption. A catalytic unit operating at 345°C (650°F) with a catalyst bed volume of 0.057 cubic meters (2.0 feet) per 0.47 standard cubic feet per second (1,000 standard cubic feet per minute [SCFM]) of waste stream can achieve 99-percent VOC destruction efficiency.

Catalytic incinerators are often used to control emissions from multiple process vents that can be collected together. Traditional thermal/catalytic incinerators are not well suited to batch applicators because the VOC concentration (and, thus, the heating value) varies dramatically during the batch cycle. A system better suited for batch processes is the thermal regenerative system.

Vapor Containment: Vapor containment is the pollution prevention practice of installing vapor return lines from process equipment to storage vessels. An example is the installation of a vapor vent from the reactor back to a raw material storage tank. This allows the displaced vapors from the reactor to return to the storage tank. The main disadvantage is the possibility of cross contamination.

POTENTIAL NATIONAL EMISSIONS REDUCTION

EPA's draft CTG presents three control options. Option 1 would provide 98-percent control of process vents; Option 2 would provide 95-percent control; and Option 3 would provide 90-percent control. These options could result in emissions reductions ranging from 52,000 Mg/year to 65,000 Mg/year in nonattainment areas, as shown below.

Summary of Control Options

Option	Control of Process Vents	Nationwide Baseline (Mg/yr)	Emission Reduction from Baseline	Reduction from Baseline (Mg/yr)
1	98%	77,000	84%	65,000
2	95%	77,000	82%	63,000
3	90%	77,000	67%	52,000

Note: Reduction from baseline is lower than the control efficiency because it is not economically feasible to treat all vents and because of lower capture efficiencies.

The cost of each control option is related to the cost of collecting and treating emissions from process

vents. The greater the amount of emissions collected from process vents and the higher the control efficiency, the higher the capital and operating cost of the control option. Therefore, Option 1 is the most costly and Option 3 is the least expensive.

In deriving these cost estimates, EPA assumed certain units would be exempted. The equations used to define the individual units assumed to be exempt from control for each option are shown below. These equations define the threshold actual average flow rate for an individual unit given its annual emissions (AE) rate and volatility stream. All units with flow rates above those calculated by these equations are exempt.

Regression Equations Used to Estimate Flow Rates As a Function of Annual Emissions

Material Volatility	CONTROL OPTION		
	1 98%	2 95%	3 90%
Low, FR =	(0.052) AE - 789	(0.065) AE - 895	(0.07) AE - 1,821
Moderate, FR =	(0.018) AE - 290	(0.026) AE - 263	(0.031) AE - 494
High, FR =	(0.015) AE - 256	(0.016) AE - 278	(0.013) AE - 301

FR = Flow rate (in SCFM)

AE = Annual emissions, in lbs/yr

COST EFFECTIVENESS

Cost effectiveness varies with the control option selected, as shown below. The cost differences between the options are related to the number of vents controlled and the degree of removal or destruction of the VOCs.

Summary of Cost Effectiveness

Control Option	National Annual Cost (\$MM)	Average Cost Effectiveness from Baseline (\$/Mg)
1	283	4,400
2	270	4,300
3	104	2,000

FEDERAL RULEMAKING AND/OR GUIDANCE DOCUMENTS

EPA issued a draft Control Techniques Guideline (CTG) in February 1993, entitled *Control of Volatile Organic Compound Emissions from Batch Processes*.

❖ For more information, contact EPA's Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711.

STATE AND LOCAL CONTROL EFFORTS

The South Coast Air Quality Management District (SCAQMD) addresses source specific operations, including batch processes. Rule 1103 requires various types of control equipment for pharmaceuticals and cosmetics manufacturing operations. Rule 1141 sets an efficiency of greater than or equal to 95 or 98 percent for resin manufacturing, depending on the equipment and process. Vinyl chloride emissions are limited to 50 grams per hour (1.8 oz/hr) for an entire plant under Rule 1163. Under Regulation XIII, all sources subject to New Source Review are required to use BACT for all processes that cause an increase in emissions of criteria pollutants, ammonia and halogenated hydrocarbons. In addition, Rule 1401 requires Best Available Control Technology for Toxics (T-BACT) and risk assessment for any new or modified source that shows a cancer risk of over one-in-one-million at any receptor location.

REFERENCES

1. U.S. Environmental Protection Agency. Office of Air Quality Planning and Standards. February 1993. *Control of Volatile Organic Compound Emissions from Batch Processes*. Draft CTG.

Table 1

Summary Table – Batch Process

Affected Facilities	Organic batch processing facilities that manufacture resins, pharmaceuticals, pesticides and synthetic organic chemicals		
Number of Affected Facilities	Over 1,500 facilities are potentially affected (22 percent resin, 35 percent pharmaceuticals, 31 percent SOCM and 12 percent pesticides).		
National Emissions Estimates	National baseline VOC emissions in nonattainment areas are estimated to be 77,000 Mg/yr.		
Potential National Emissions Reduction	Based upon the three control options included in EPA's draft CTG, potential VOC reductions are: Option 1 - 84% or 65,000 Mg/yr; Option 2 - 82% or 63,000 Mg/yr; and Option 3 - 67% or 52,000 Mg/yr.		
Cost Effectiveness	Capital (\$MM)	Cost Effectiveness (\$/Mg)	
	Option 1	283	4,400
	Option 2	270	4,300
	Option 3	104	2,000
Federal Rulemaking and/or Guidance Documents	EPA issued a draft CTG in February 1993.		
State and Local Control Efforts	SCAQMD Regulation XI: Rule 1103 - Control equipment for pharmaceuticals and cosmetics manufacturing operations. Rule 1141 - At least 98-percent control for resin manufacturing. Rule 1163 - Total vinyl chloride emissions no greater than 50 grams/hr for entire facility.		
	SCAQMD Regulation XIII: NSR - BACT for all batch or continuous processes. Rule 1401 - T-BACT and risk assessment for any new or modified source.		
STAPPA/ALAPCO Recommendation	Set limits of 98-percent control efficiency; provide exemptions based on considerations of volatility, annual emissions and flow rate.		

Coke By-Product Recovery Plants

DESCRIPTION OF SOURCE CATEGORY

A coke by-product recovery plant is any plant designed and operated for the purpose of separating and recovering coal tar derivatives, or by-products, produced during the coking process. The gaseous mixture leaving coking ovens contains coke oven gas, water vapor, tar, light oils, solid particles of coal dust, heavy hydrocarbons and complex carbon components. Products recovered by coke by-product recovery plants include benzene, toluene, xylenes, creosote oils, creosols, cresylic acid, naphthalene, phenols, xylols, pyridine, quinoline, medium and hard pitches and roof and road tars.

GEOGRAPHIC DISTRIBUTION OF SOURCES

In 1989 there were 36 coke by-product recovery plants located in 12 states, including 25 furnace plants and 11 foundry plants. Furnace coke by-product recovery plants are concentrated in Ohio, Pennsylvania, Illinois, Indiana and West Virginia, while foundry coke by-product recovery plants are located in various states, including Alabama, Pennsylvania and Indiana.

NATIONAL EMISSIONS ESTIMATES

In 1988, nationwide emissions from 44 plants were estimated at 28,700 tons/year for benzene and 188,500 tons/year for volatile organic compounds (VOCs), including benzene. Coke production capacity in 1988 was estimated at 56.1 million tons/year. This data base was revised in 1989 for a total of 36 plants with an estimated coke production capacity of 38.6 million tons/year. In 1989, nationwide emissions were estimated at 18,800 tons/year for benzene and 129,000 tons/year for VOCs. VOC emissions from furnace and foundry plants were estimated at 116,800 tons/year and 12,100 tons/year, respectively.

AVAILABLE CONTROL STRATEGIES

Title III of the Clean Air Act Amendments of 1990 requires the imposition of Maximum Achievable Control Technology (MACT) standards for source categories that emit listed hazardous air pollutants. Coke by-product recovery plants are affected by this requirement because they emit benzene, one of the listed hazardous air pollutants.

Table 1 presents uncontrolled VOC emission estimates for coke by-product recovery plants, applicable control techniques and their associated control efficiencies, the

STAPPA/ALAPCO Recommendation

► State and local agencies should implement the NESHAP for this source category.

resulting controlled emission estimates and cost-effectiveness values.

POTENTIAL NATIONAL EMISSIONS REDUCTION

Significant reductions can be achieved by implementing the MACT standard for this source category.

COST EFFECTIVENESS

Cost-effectiveness values for controlling VOC emissions vary from process to process and according to the control strategy employed. Table 1 identifies the cost effectiveness of controlling VOC emissions from coke by-product recovery plants.

FEDERAL RULEMAKING AND/OR GUIDANCE DOCUMENTS

The National Emission Standards for Hazardous Air Pollutants (NESHAP) for benzene emissions from coke by-product recovery plants was proposed on July 28, 1988 and promulgated on September 14, 1989 (54 FR 38044).

STATE AND LOCAL CONTROL EFFORTS

All states with coke by-product recovery plants are implementing the federal regulations.

REFERENCES

1. U.S. Environmental Protection Agency. August 1989. *Benzene Emissions from Coke By-Product Recovery Plants, Benzene Storage Vessels, Equipment, Leaks, and Ethylbenzene/Styrene Process Vents*. Background Information and Responses to Technical Comments for 1989 Final Decisions. 450/2-89-31.
2. U.S. Environmental Protection Agency. May 1984. *Benzene Emissions from Coke By-Product Recovery Plants - Background Information for Proposed Standards*. 450/3-83-16a.

COKE BY-PRODUCT RECOVERY PLANTS

Table 1

VOC Emissions and Cost Effectiveness

Emission Source	Control Efficiency	Uncontrolled Emissions ^a	Controlled VOC Emissions ^a	Cost Effectiveness ^b
Final cooler cooling tower and naphthalene processing and handling	Tar-bottom final cooler 81% Wash-oil final cooler 100%	98,200	18,700 0	10 40
Tar decanter, tar intercepting sump and flushing-liquor circulating tank	Gas blanketing 95%	11,480	380	50
Tar storage tanks and tar-decating tanks	Gas blanketing 98%	21,370	430	70
Light-oil condenser, light-oil decanter, wash-oil decanter and wash-oil circulation tanks	Gas blanketing 98%	3,080	70	180
Excess ammonia liquor storage tank	Gas blanketing 98%	380	8	1,640
Light-oil storage tanks and BTX storage tanks	Gas blanketing 98%	260	6	3,300
Benzene storage tanks	N ₂ gas blanketing 98%	17	0	3,420
Light-oil sump	Cover 98%	570	10	510
Pumps		420		
	Quarterly inspections 71%		120	80
	Monthly inspections 83%		70	80
	Dual mechanical seals 100%		0	2,030
Valves		280		
	Quarterly inspections 63%		100	(100) ^c
	Monthly inspections 73%		80	(80) ^c
	Sealed-bellows valves 100%		0	12,180
Exhausters		20		
	Quarterly inspections 55%		9	1,080
	Monthly inspections 64%		7	1,920
	Degassing reservoir 100%		0	17,590
Pressure-relief devices		190		
	Quarterly inspections 44%		110	(280) ^c
	Monthly inspections 52%		90	(210) ^c
	Rupture disc system 100%		0	640
Sampling connection system	Cap or plug 100%	40	0	800
Open-ended lines	Cap or plug 100%	12	0	460
Naphthalene processing and handling	Mixer-settler 100%	2,100	0	610

^a Emissions are in Mg/yr.

^b Cost effectiveness is in 1984 dollars.

^c Costs in parentheses indicate savings.

Table 2.....**Summary Table – Coke By-Product Recovery Plants**

Affected Facilities	All coke by-product recovery plants.
Number of Affected Facilities	Approximately 36 plants in 12 states.
National Emissions Estimates	In 1989, VOC emission estimated to be 129,000 tons/year.
100 TPY Source Size	All sources.
Potential Emissions Reduction Per Facility	VOC reductions discussed by process, not by facility.
Cost Effectiveness	See Table 1 for cost effectiveness by process emission control.
Federal Rulemaking and/or Guidance Documents	NESHAP for benzene emissions for coke by-product recovery plants implemented on September 14, 1989 (54 FR 38044).
State and Local Control Efforts	States with coke by-product recovery plants are implementing federal regulations.
STAPPA/ALAPCO Recommendation	Implement the NESHAP for this source category.

Coke Oven Batteries

DESCRIPTION OF SOURCE CATEGORY

Coke is produced by the destructive distillation of coal in coke ovens. A coke oven battery is a series of 10 to 100 coke ovens operated together. Prepared coal is "coked," or heated in an oxygen-free atmosphere, until the volatile components in the coal are evaporated. Most metallurgical coke is used in iron and steel industry processes, such as blast furnaces, sinter plants and foundries, to reduce iron ore to iron. Coke oven gas is the most commonly used fuel for underfiring coke ovens; approximately 40 percent of coke oven gas is used to heat the coke ovens, normally after the removal of its byproducts.

Emissions of volatile organic compounds (VOCs) result from several coking operations, including coke oven charging, oven leakage during the coking period, coke removal and hot coke quenching. Of these four sources, coke oven charging has been found to be a particularly large contributor of VOC emissions. Coke ovens are normally charged shortly after discharging the previous charge, while the coke oven is extremely hot. During charging, the coal that enters the coke oven first begins to bake against the hot oven walls, releasing emissions as charging continues.

During the coking cycle, VOC emissions from the thermal distillation process can leak through poorly sealed doors, charge lids and offtake caps; from the main collecting duct; and through cracks that may develop in oven brickwork.

VOC emissions are normally light when coke is pushed out of the coke oven and into the quench car. However, emissions tend to be heavy if the coke mass is not fully coked (i.e., if carbonization of the coal is incomplete). Coke in this condition is called "green coke." Green coke results from either poor coke oven maintenance or poor operating procedures.

Gaseous emissions collected from coke ovens during the coking process are subjected to various recovery processes for separating ammonia, coke oven gas, tar, phenol, light oils (benzene, toluene, xylene) and pyridine. These processes are additional sources of VOC emissions.

GEOGRAPHIC DISTRIBUTION OF SOURCES

In 1987, there were 40 plants operating in at least 13 states. Coke manufacturing facilities are concentrated in the midwest, on the east coast and in the mid-south.

STAPPA/ALAPCO Recommendation

► State and local agencies should implement the recently proposed NESHAP.

AVAILABLE CONTROL STRATEGIES

The primary control strategy for controlling emissions during coal charging is to conduct staged charging to prevent overloading scrubber systems. Oven leakage during the coking period can be minimized by maintaining oven seals and by following proper operating and maintenance procedures.

To control coke removal emissions, many facilities use mobile scrubber cars with hoods, shed enclosures evacuated to a gas cleaning device or traveling hoods with a fixed duct leading to a stationary gas cleaner.

Hot coke quenching produces relatively small levels of VOC emissions if the coal has been properly carbonized in the coke oven. Production of green coke (and the release of VOC emissions) can be minimized by having an effective maintenance program and by following proper operating procedures.

POTENTIAL NATIONAL EMISSIONS REDUCTION

Few data exist on the potential national VOC emissions reductions from coke batteries. However, targeted performance levels set by the U.S. Environmental Protection Agency (EPA) in the proposed National Emission Standard for Hazardous Air Pollutants (NESHAP) for coke batteries (57 FR 57534, December 4, 1992) would require additional emissions reductions of 1.3 percent for doors, 2.3 percent for lids, 4.5 percent for offtake caps and 4 percent during charging, above the current estimated control efficiency of 90 percent.

Current controls, consisting of modified coke battery hardware, installed pollution control devices and production practices are estimated to control 90 percent of potential emissions from charging operations, door leaks and topside leaks. Table 1 displays additional potential reductions that would be required under the proposed NESHAP.

EPA believes that visible emissions represent the most practical means of assessing the performance of coke

oven emissions controls. If VOC emissions have a linear relationship with visible emissions, then the proposed visual emission reduction requirements will also reduce VOC emissions proportionally at process emission points where VOC emissions have been identified.

EPA has found that there are technical and economical difficulties related to collecting and measuring coke oven gases, due in part to the hostile environment in the immediate operating area of an oven. However, efforts are underway to develop testing procedures for coke batteries that should improve the reliability of emission test data. These efforts should result in more accurate information on potential VOC emissions reductions from coke batteries.

COST EFFECTIVENESS

Although the primary reason for regulating coke ovens is to control air toxics, other benefits of regulation include reducing VOC emissions. Control costs to reduce VOC emissions resulting from charging, door leaks and topside leaks are estimated at \$37,120/ton.

FEDERAL RULEMAKING AND/OR GUIDANCE DOCUMENTS

EPA proposed a NESHAP for coke batteries in December 1992 (57 FR 57534, December 4, 1992).

❖ For further information, contact Gail Lacy, U.S. Environmental Protection Agency, Emission Standards Division, (MD-13), Research Triangle Park, NC 27711 (telephone: 919/541-5261).

STATE AND LOCAL CONTROL EFFORTS

State and local regulations generally focus on controlling visible emissions, without reference to regulating VOC emissions.

REFERENCES

1. Lake Michigan Air Directors Consortium. April 16, 1993. *Evaluation of Possible Control Measures - Control of Emissions from Coke Batteries [VOC]*. Draft.
2. SRI International. May 1987. *Coke and Coke Products, Chemical Economics Handbook*.

COKE OVEN BATTERIES

Table 1.....
Existing and Proposed NESHAP Limits for Coke Oven Batteries^a

EMISSION POINT	EXISTING LIMIT	MACT 31-DEC-95	MACT 01-JAN-03	EXTENSION TRACK 15-NOV-93	EXTENSION TRACK 01-JAN-98	EXTENSION TRACK 01-JAN-10
Door leaks	10% + 4 leaking doors - one pass	Not > 6% leaking doors (tall batteries)	Not > 5.5% leaking doors	Not > 7% leaking doors	Not > 4.4% leaking doors	Not > 4% leaking doors
		Not > 5.5% leaking doors (short batteries)	Not > 5% leaking doors	Not > 7% leaking doors	Not > 3.8% leaking doors	Not > 3.3% leaking doors
Charging	No visible emissions for more than 125 seconds from 5 cons. charges (one charge out of 20 cons. charges exempt)	12 seconds	12 seconds	12 seconds	12 seconds	12 seconds
		30-day rolling average				
Lids	Not > 3% leaking lids one pass	Not > 0.6% leaking lids	Not > 0.6% leaking lids	Not > 0.83% leaking lids	Not > 0.4% leaking lids	Not > 0.4% leaking lids
		30-day rolling average				
Offtakes	Not > 10% leaking offtakes - one pass	Not > 3% leaking offtakes	Not > 3% leaking offtakes	Not > 4.2% leaking offtakes	Not > 2.5% leaking offtakes	Not > 2.5% leaking offtakes
		30-day rolling average				
Gas Collector Main	No visible emissions for more than 3 points on the main.	Inspect for leak at least once a day. Repair within specified time period. Check gas collector main pressure.				
Combustion Stacks	Particulate matter mass emission limit. Visible emission limit.	Will be developed and promulgated before 2000.				
Quenching	1. TDS Conc. of quench water as applied not to exceed 1500 mg/l. 2. Visible emission limit.	Will be developed and promulgated before 2000.				
Bypass/Bleeder Stacks	General opacity limit.	Install flare system meeting the specified design and operating requirements. No visible emissions except for periods not to exceed a total of 5 minutes during any 2 consecutive hours				
By-product Recovery Plants	Emission capture and control requirements, leak detection and repair program for benzene handling components.					

^a See Reference 1.

Table 2**Summary Table – Coke Oven Batteries**

Affected Facilities	Coke batteries.
Number of Affected Facilities	Approximately 40 facilities in at least 13 states.
Cost Effectiveness	\$37,120 per ton of VOC removed.
Federal Rulemaking Guidance and/or Documents	NESHAP for coke batteries proposed on December 4, 1992.
State and Local Control Efforts	Agencies generally control visual emissions.
STAPPA/ALAPCO Recommendation	Implement the proposed NESHAP for this source category.

Commercial Ethylene Oxide Sterilization

DESCRIPTION OF SOURCE CATEGORY

This category addresses the use of ethylene oxide (EtO) as a sterilant/fumigant in the production of medical equipment (e.g., syringes and surgical gloves), spices, cosmetics, pharmaceuticals and in miscellaneous other operations. Typically, EtO is used as a sterilant for heat-sensitive or moisture-sensitive materials or as a fumigant to control microorganisms or insects. Materials may be sterilized at the facility that produces or uses the product or by contract sterilizers (i.e., firms under contract to sterilize products manufactured by other companies). Libraries and museums may also use EtO to fumigate books and other historical items. State departments of agriculture have also controlled diseases of bees by fumigating beehives with EtO.

Table 1 lists the types of companies that use ethylene oxide sterilizers, their Standard Industrial Classification (SIC) codes and the number of facilities in each category.

GEOGRAPHIC DISTRIBUTION OF SOURCES

Commercial EtO sterilization facilities are located in 41 states and Puerto Rico; Table 2 shows the number of facilities in each state.

NATIONAL EMISSIONS ESTIMATES

Annual EtO emissions from commercial sterilization facilities are estimated at 1,182 tons per year. Other compounds emitted from EtO sterilization facilities are dichlorodifluoromethane and carbon dioxide, neither of which are photochemically reactive.

AVAILABLE CONTROL STRATEGIES

The three main techniques used to control EtO emissions from sterilizer vents are hydrolysis, in which EtO is catalytically hydrolyzed to form ethylene glycol; thermal or catalytic oxidation, in which EtO is converted into carbon dioxide and water; and condensation, in which the sterilant gas mixture is recovered. A fourth control technique for sterilizer vents involves the use of a gas/solid reactor system that chemically reacts with EtO and binds it to the solid packing of the reactor. This technique is generally used in series with one of the other three techniques. Its main function is to remove residual EtO. With the gas/solid reactor, there is no liquid waste produced; the solid waste is returned to the vendor for recycling.

STAPPA/ALAPCO Recommendation

► State and local agencies should consider requiring 99-percent control from the main sterilizer vent and vacuum pump drains from EtO sterilizers using greater than 600 pounds per year of EtO.

Standards Division (MD-13), Research Triangle Park, NC 27711 (telephone: 919/541-0837).

STATE AND LOCAL CONTROL EFFORTS

Existing state and local regulations for ethylene oxide emissions are shown in Table 3. In addition, several states are currently regulating EtO as part of their state air toxic programs.

REFERENCES

1. U.S. Environmental Protection Agency. Office of Air Quality Planning and Standards. October 1992. *Ethylene Oxide Emissions from Commercial Sterilization/Fumigation Operations*. 453/D-93-016.

POTENTIAL NATIONAL EMISSIONS REDUCTION

A standard implemented at the Maximum Achievable Control Technology (MACT) floor would reduce EtO emissions by 72 percent, or 800 tons per year.

The reduction potential of the three main reduction technologies are as follows:

- Hydrolysis using a packed bed scrubber - 99 percent;
- Hydrolysis using a reaction/detoxification tower - 99 percent;
- Hydrolysis using a caustic scrubber - 50 percent;
- Oxidation using a flare - 98 percent;
- Oxidation using a catalytic oxidizer - 99 percent; and
- Condensation/reclamation - 50 to 83 percent.

COST EFFECTIVENESS

Cost effectiveness at the MACT floor is approximately \$2,200 per ton of EtO reduced for the main sterilizer vent and \$54,000 per ton reduced for the aeration vent.

FEDERAL RULEMAKING AND/OR GUIDANCE DOCUMENTS

The U.S. Environmental Protection Agency (EPA) is expected to propose a National Emission Standard for Hazardous Air Pollutants (NESHAP) in February 1994, with final promulgation anticipated by February 1995.

❖ *For more information, contact David Markwordt, U.S. Environmental Protection Agency, Emission*

COMMERCIAL ETHYLENE OXIDE STERILIZATION

Table 1

**Types and Number of Commercial Facilities
Using Ethylene Oxide Sterilization and
Corresponding SIC Codes**

Industry	No. of Facilities	SIC Code
Medical equipment suppliers	61	3841, 3842
Pharmaceuticals	39	2834, 5122, 2831, 2833
Other health-related industries	24	3079, 3693, 5086, 2211, 2821, 2879, 3069, 3569, 3677, 3999
Spice manufacturers	23	2099, 5149, 2034, 2035, 2046
Contract sterilizers	17	7399, 7218, 8091
Libraries, museums and archives	13	8411, 8231
Laboratories (research, testing and animal breeding)	11	0279, 7391, 8071, 8922, 7397
State departments of agriculture	8	9641
TOTAL	196	

Table 2

State-by-State Distribution of EtO Sterilization Facilities

Alabama	1	Maine	1	Ohio	2
Arizona	3	Maryland	5	Oregon	1
Arkansas	2	Massachusetts	9	Pennsylvania	9
California	19	Michigan	8	Puerto Rico	14
Colorado	3	Minnesota	6	Rhode Island	2
Connecticut	6	Mississippi	2	South Carolina	2
Delaware	2	Missouri	5	South Dakota	1
Florida	5	Nevada	1	Tennessee	3
Georgia	4	New Hampshire	2	Texas	12
Hawaii	1	New Jersey	17	Utah	1
Illinois	8	New Mexico	1	Virginia	5
Indiana	4	New York	13	Washington	2
Iowa	3	North Carolina	7	Wisconsin	1
Kentucky	1	North Dakota	1	West Virginia	1

Table 3

State and Local Regulations for Ethylene Oxide Emissions^a

Area	Regulatory Description															
California ^b	<p>Control is based on annual EtO usage.</p> <table><thead><tr><th>Annual Usage (lbs)</th><th>Sterilizer Control</th><th>Aeration Control</th></tr></thead><tbody><tr><td><25</td><td>No control</td><td>No control</td></tr><tr><td>25-600</td><td>99%</td><td>No control</td></tr><tr><td>600-5,000</td><td>99.9%</td><td>95%</td></tr><tr><td>>5,000</td><td>99.9%</td><td>95%</td></tr></tbody></table>	Annual Usage (lbs)	Sterilizer Control	Aeration Control	<25	No control	No control	25-600	99%	No control	600-5,000	99.9%	95%	>5,000	99.9%	95%
Annual Usage (lbs)	Sterilizer Control	Aeration Control														
<25	No control	No control														
25-600	99%	No control														
600-5,000	99.9%	95%														
>5,000	99.9%	95%														
Colorado	EtO regulated as a VOC; RACT required for new sources.															
Connecticut	BACT required for all new or modified sources exceeding a maximum allowable stack concentration (MASC). MASC is calculated using exhaust gas flow rate, stack height and the distance from the discharge point to the property line. MASC would be exceeded for industrial sterilizers using typical sterilization cycles; therefore, BACT is required on new or modified sources. Existing sources exceeding the maximum allowable ambient concentration of 0.01 ppm have three years to comply with orders given by the Connecticut Department of Environmental Protection.															
Florida ^b	Maximum risk level of 10 ⁻⁶ for new or modified sources.															
Michigan ^b	BACT for all new sources. Requires emissions be indictable or subjected to risk analysis (maximum allowable risk level is 10 ⁻⁶). For industrial sterilizers using typical sterilization cycles, a control efficiency based on a risk assessment analysis would be greater than 99 percent by weight.															
Missouri	EtO regulated as a VOC.															
New Jersey	EtO regulated as a VOC. BACT required for new or modified sources.															
New York ^c	New or modified sources must achieve 99-percent control or greater, or BACT (also at permit reviews). Maximum annual impact must not exceed guideline Acceptable Ambient Level (AAL) of 6.67 µg/m3 (a revised AAL of 0.019 µg/m3 is anticipated for the next edition of Air Guide-1). Certificate of operation includes the following statement: "Should significant new scientific evidence from a recognized institution result in the decision by DEC that lower ambient levels must be established, it may be necessary to reduce emissions from this source prior to the expiration of this Certification of Operation."															
Oklahoma	Maximum ambient air concentration at property line is 1/100 of threshold limit value.															
Puerto Rico	EtO regulated as a VOC; emission controls required for emissions greater than 3 lbs/hr or 15 lbs/day.															
Rhode Island ^c	Maximum risk level of 10 ⁻⁶ for new and existing sources; if BACT is used, may consider 10 ⁻⁵ risk level.															
South Coast Air Quality Management District ^d	Pursuant to SCAQMD Rule 1405, "Control of Ethylene Oxide and Chlorofluorocarbon Emissions from Sterilization or Fumigation Processes," any facility using EtO sterilizers shall vent the sterilizer to control equipment with an efficiency of 99 percent to 99.9 percent, depending on the amount of EtO used. The three most common types of EtO control are catalytic oxidation, acid scrubbing and reclamation. Catalytic oxidation burns the EtO at low temperatures (300°F to 500°F) through the presence of a catalyst. An acid scrubber reduces EtO emissions by hydrolyzing EtO into ethylene glycol using an acid catalyst in solution with water. In an EtO reclamation system, the EtO gas is dehumidified, compressed, cooled and condensed back into liquid form. The condensed liquid is then pumped into a tank for reuse.															
Tennessee	EtO regulated under standards for process and nonprocess emissions.															
Texas	BACT required for all new sources.															
Utah	BACT required for all new or modified sources. BACT requirements to go into effect for existing sources. (Following the programs developed in New York.)															
Vermont	EtO regulated as a VOC.															
Virginia	For any 24-hour concentration exceeding 1/100 of the TLV-TWA, both existing and new facilities are required to control emissions as directed by the Virginia Air Pollution Control Board.															
Wisconsin ^d	BACT required for all new and existing sources that emit >25 lbs/yr.															
Wyoming	BACT required for all new sources. Controls must meet AAL at property line.															

^aSee Reference 1. Information obtained from 1986 and 1987 data unless stated otherwise.^bInformation obtained from state contacts in May 1990.^cInformation obtained from state contacts in February 1989.^dInformation obtained from state contacts in July 1993; this information is not included in original table found in Reference 1.

Table 4.....

Summary Table -- Commercial Ethylene Oxide Sterilization

Affected Facilities	Commercial sterilization facilities that use EtO as a sterilant for heat- or moisture-sensitive materials or as a fumigant to control microorganisms or insects.			
Number of Affected Facilities	196 facilities located in 41 states and Puerto Rico.			
National Emissions Estimates	1,182 TPY of VOCs.			
VOC Emissions		Small	Medium	Large
Range and Potential	Facility EtO use, tpy	1.0	4.4	74.5
Emissions Reduction	Total emission reduction,			
Per Facility	tpy	0	4.11	70.1
Cost Effectiveness	Total annual costs: \$6.4 million. Cost effectiveness: \$6,500 per ton.			
Federal Rulemaking and/or Guidance Documents	EPA expects to propose a NESHAP by February 1994, with final promulgation anticipated by February 1995.			
State and Local Control Efforts	Eighteen state and local agencies and Puerto Rico currently have regulations controlling emissions from EtO sterilization facilities (see Table 3).			
STAPPA/ALAPCO Recommendation	Require 99-percent control from the main sterilizer vent and vacuum pump drains from EtO sterilizers using greater than 600 lbs/yr of EtO.			

Consumer and Commercial Products

DESCRIPTION OF SOURCE CATEGORY

Consumer and commercial products are those items sold to retail customers for household, personal or automotive use, along with the products marketed by wholesale distributors for use in commercial or institutional settings, such as beauty shops, schools and hospitals. Volatile organic compound (VOC) emissions from these products are the result of the evaporation of propellant and organic solvents during use.

Consumer and commercial products represent a diverse area source and include personal care products, automotive and industrial maintenance products, household maintenance products, pesticide products and aerosol paints. (Aerosol paints are addressed in a separate chapter.) There are several different definitions of consumer and commercial products. For the purpose of this chapter, consumer and commercial products consist of products included in one of the previously mentioned groups, excluding aerosol paints.

GEOGRAPHIC DISTRIBUTION OF SOURCES

Consumer and commercial products are distributed nationally, with the volume of distribution generally proportional to population.

NATIONAL EMISSIONS ESTIMATES

Emissions from consumer products result from many small point sources distributed over a large area that collectively function as an area source. Emissions can be significant; the U.S. Environmental Protection Agency (EPA) estimates annual VOC emissions from consumer and commercial products to be approximately 4.8 pounds per person per year. The California Air Resources Board (CARB) estimates emissions from consumer products to be approximately 200 tons per day in that state. A similar distribution throughout the United States would equate to about 1,800 tons per day or 660,000 tons per year nationwide.

AVAILABLE CONTROL STRATEGIES

Reductions in VOC emissions from consumer products can be achieved in several ways, including reformulation of

the product, alternative and modified dispensing or delivery systems or product substitution.

Several methods are available to reformulate products, including the partial or complete replacement of VOC solvents with water or another non-VOC material. In some cases, water may be added to a formula by creating an emulsion system or by changing to water-compatible active ingredients and propellants. Another method is to replace VOC propellants with non-VOC propellants such as carbon dioxide, HFC-152a or compressed air.

Alternative application techniques modify the product delivery system and include traditional as well as innovative ways to reduce VOC emissions. Methods include substituting a handpump for the propellant to deliver the product or changing the product from an aerosol to a solid, liquid or powder. In some cases the active ingredients can be increased, thereby reducing the amount of the product needed for a specific use.

POTENTIAL NATIONAL EMISSIONS REDUCTION

By using CARB's "Regulation for Reducing Volatile Organic Compound Emissions from Consumer Products," an emissions reduction estimate is possible for the 27 commercial and consumer products that are regulated under the California rules. Assuming that consumer products are distributed consistently throughout the United States, implementation of the California rule would result in a reduction of approximately 28 percent in the inventory by 1999.

COST EFFECTIVENESS

As part of the regulatory development process, CARB calculated the cost effectiveness of its consumer products regulation. CARB assumed that manufacturers would reformulate a product to a similar product form, with no additional capital or raw material costs associated with the reformulation. The agency also assumed that manufacturers would market the reformulated product nationally. The cost effectiveness for the consumer product regulation ranged from a net savings to a cost of up to \$3,400 per ton of VOC removed. The cost-effectiveness range reflects the best estimate based on the data available and the uncertainty in the cost of reformulation for the wide variety of products covered under the regulation.

FEDERAL RULEMAKING AND/OR GUIDANCE DOCUMENTS

Section 183(e) of the Clean Air Act requires EPA to conduct a study on commercial and consumer products.

STAPPA/ALAPCO Recommendation

► State and local agencies should consider adoption of the California consumer products regulations. A summary of the key provisions of the rule are provided in Table 1. California estimates that this rule will result in an estimated 45-percent reduction in emissions from the regulated categories and a reduction of approximately 28 percent in the total consumer and commercial products inventory (excluding aerosol paints), which is 200 tons per day in California. Based upon the assumptions that consumer products are distributed uniformly throughout the country and that consumption is proportional to population, the national emissions reductions from the adoption of this regulation would be approximately 500 tons per day or 180,000 tons per year.

Based on the study, EPA is required to divide this category into four groups and regulate one set every two years until all four are regulated. It is not now known which consumer and commercial products will be regulated or if EPA will choose instead to issue a Control Techniques Guideline (CTG) in lieu of a federal regulation.

❖ *For more information on EPA programs in this area, contact Bruce Moore, U.S. Environmental Protection Agency, Emission Standards Division (MD-13), Research Triangle Park, NC 27711 (telephone: 919/541-0283).*

STATE AND LOCAL CONTROL EFFORTS

Several state and local agencies have adopted rules to regulate various consumer products. New York's first consumer products rule, 6 NYCRR 235, for consumer insecticides, air fresheners and disinfectants was adopted in September 1988. New York also has adopted a regulation to limit the VOC content of antiperspirants, deodorants and hair sprays. Since the late 1980s, Texas has limited

VOCs in windshield washer fluids in Dallas and Tarrant Counties; other areas in Texas have recently followed suit. The Lake Michigan Ozone Control Program has investigated the control of consumer products as a strategy for obtaining VOC reductions. The South Coast Air Quality Management District (SCAQMD) has adopted a regulation to limit the emissions from charcoal lighter materials, which has been in effect since January 1992. California has adopted the most comprehensive regulation for consumer products, which includes VOC limits for 27 different consumer product types and incorporates the charcoal lighter material emissions limits from the SCAQMD rule. Adoption of the California regulations began in 1990, with implementation of the standards beginning on January 6, 1993.

REFERENCES

1. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. April 1989. *Compilation and Speciation of National Emissions Factors for Consumer/Commercial Solvent Use*. EPA-450/2-89-008.
2. Lake Michigan Air Directors Consortium. April 16, 1993. *Evaluation of Possible Control Measures for Commercial/Consumer Solvents*. Draft.
3. California Air Resources Board. Regulation for Reducing VOC Emissions from Consumer Product. California Code of Regulations, Title 17, Subchapter 8.5, Article 2, Sections 94500-94517.
4. New York State Department of Conservation. *Commercial and Consumer Products, Rules and Regulations of the State of New York*. Title 6, Chapter III, Subchapter A, Part 235.

Table 1

California Air Resources Board Standards for Consumer Products

No person shall sell, supply, offer for sale or manufacture for sale any consumer product which, at the time of sale or manufacture, contains volatile organic compounds in excess of the limits specified in the following Table of Standards after the specified effective dates.

Table of Standards- Phase I
(percent VOC by weight)

Product Category	1/1/93	1/1/94	Future Standard (effective date)
Air Fresheners			
Single-Phase Aerosols	70		30 (1/1/96)
Double-Phase Aerosols	30		
Liquids/Pump Sprays	18		
Solids/Gels	3		
Dual-Purpose Air Freshener/Disinfectant Aerosols		60	
Automotive Windshield Washer Fluids:			
Type A Areas ^a	35		
All Other Areas	10		
Bathroom and Tile Cleaners			
Aerosols		7	
All Other Forms		5	
Engine Degreasers	75		50 (1/1/96)
Floor Polishes/Waxes			
Products for Flexible Flooring Materials		7	
Products for Nonresilient Flooring		10	
Wood Floor Wax		90	
Furniture Maintenance Products			
Aerosols		25	
All Other Forms except Solid or Paste Forms		7	
General Purpose Cleaners		10	
Glass Cleaners			
Aerosols	12		
All other forms	8		6 (1/1/96)
Hairsprays	80		55 (1/1/98)
Hair Mousses		16	
Hair Styling Gels		6	
Laundry Prewash			
Aerosols/Solids		22	
All Other Forms		5	
Nail Polish Removers		85	75 (1/1/96)

- continued

Table 1 - continued.....

Product Category	1/1/93	1/1/94	Future Standard (effective date)
Oven Cleaners			
Aerosols/Pump Sprays	8		
Liquids	5		
Insect Repellents Aerosols		65	
Shaving Creams		5	

^aType A Areas include those with colder wintertime climates and are defined in Title 17, California Code of Regulations, Sections 60105, 60108, 60111, and 60113.

Table of Standards - Phase II

(percent VOC by weight)

Product Category	1/1/95	Future Standard (effective date)
Aerosol Cooking Sprays	18	
Automotive Brake Cleaners		50 (1/1/97)
Charcoal Lighter Material ^a		
Carburetor-Choke Cleaners	75	
Dusting Aids		
Aerosol	35	25 (1/1/97)
All Other Forms	7	
Fabric Protectants	75	60 (1/1/97)
Household Adhesives		
Aerosol	75	25 (1/1/97)
Contact	80	
Construction and Panel	40	
General Purpose	10	
Insecticides		
Crawling Bug	40	20 (1/1/98)
Flea and Tick	25	
Flying Bug	35	
Foggers	45	
Lawn and Garden	20	
Laundry Starch Products	5	
Personal Fragrance Products		
Products with 20% or less fragrance	80	75 (1/1/99)
Products with more than 20% fragrance	70	65(1/1/99)

^bThe standard for charcoal lighter material is an emission-based limit and restricts the sale of any charcoal lighter material to those products that are certified to have less than or equal to 0.020 pound of VOC per start.

Note: The Phase I and Phase II consumer products regulations also include an exemption for VOCs with vapor pressures less than 0.1 millimeters of mercury.

Table 1 - continued.....

Deodorants and Antiperspirants^a

(percent VOC by weight)

Product Form	Immediately Upon the Effective Date of this Article	Effective Dates				
		12/31/1992 HVOC ^b	MVOC ^c	1/1/1995 HVOC ^b	MVOC ^c	
Aerosol product						
Antiperspirant	current level ^d	60	20	0	10	
Deodorant	current level	20	20	0	10	
Non-aerosol product		current level	0	0	0	0

^aVOCs with vapor pressures 2.0 mmHg or less are exempt.

^bHigh volatility organic compounds (i.e., any organic compound that exerts a vapor pressure greater than 80 mmHg when measured at 20°C).

^cMedium volatility organic compounds (i.e., any organic compound that exerts a vapor pressure greater than 2 mmHg and less than or equal to 80 mmHg when measured at 20°C).

^dCurrent level is the VOC content of each existing product by manufacturer, package type and label.

Table 2
Summary Table – Consumer and Commercial Products

Affected Facilities	Items sold to retail customers for household, personal or automotive use and products marketed by wholesale distributors for use in commercial or institutional settings, such as beauty shops, schools and hospitals. Includes personal care products, automotive supplies, industrial maintenance products, household maintenance products, pesticides and aerosol paints.
Number of Affected Facilities	Consumer and commercial products are distributed nationally, with the volume of distribution generally proportional to population.
National Emissions Estimates	EPA estimates annual VOC emissions of 4.8 lbs per person. California estimates emissions of 200 tons per day in that state, which would equate to 1,800 tons per day or 660,000 tons per year nationwide.
Potential National Emissions Reduction	National implementation of California's rule could result in a VOC reduction of approximately 28 percent in the national inventory.
Cost Effectiveness	California estimated the cost effectiveness of reformulation to range from a net savings to a cost of \$3,400 per ton of VOC removed.
Federal Rulemaking and/or Guidance Documents	Section 183(e) of the Clean Air Act calls for EPA to study consumer and commercial products. Based on the study, EPA must divide the category into four groups and regulate one set every two years until all four are regulated. It is unknown which products will be regulated or if EPA will instead issue a CTG.
State and Local Control Efforts	California limits VOCs from 27 different consumer product types. This is the most comprehensive state or local regulation. New York has adopted rules to regulate consumer insecticides, air fresheners and disinfectants, antiperspirants, deodorants and hair sprays. Texas limits VOCs in windshield washer fluids in certain areas. SCAQMD limits emissions from charcoal lighter materials. The Lake Michigan Ozone Control Program has investigated the control of consumer products.
STAPPA/ALAPCO Recommendation	Consider adopting the California regulations.

Degreasing

DESCRIPTION OF SOURCE CATEGORY

Surface cleaning, or degreasing, includes the solvent cleaning or conditioning of metal surfaces and parts, fabricated plastics, electronic and electrical components and other nonporous substrates. The cleaning processes are designed to remove foreign materials such as oils, grease, waxes and moisture. Cleaning is usually done in preparation for further treatment, such as painting, electroplating, galvanizing, anodizing or applying conversion coatings.

Degreasing is a part of virtually all metal-working processes. It is used in the primary metal industries and in the manufacture of fabricated metal products, industrial and commercial machinery and computer equipment, electronic equipment, transportation equipment, furniture and fixtures and various other products.

A Control Techniques Guideline (CTG) published by the U.S. Environmental Protection Agency (EPA) in 1977 presents guidelines for controlling volatile organic compound emissions from solvent metal cleaning (degreasing) operations. The CTG covers three categories of cleaners: cold cleaners, which remove soils from a metal surface by brushing, flushing or immersion while maintaining the solvent below its boiling point; open-top vapor

degreasers (OTVD), which use hot solvent vapor to clean and remove soils from batch metal parts; and conveyorized degreasers, which clean and remove soils from metal parts using either cold or vaporized solvents in a continuous process.

GEOGRAPHIC DISTRIBUTION OF SOURCES

There are about 1.3 million cold-cleaning units in the United States; 70 percent of these (910,000) are used for maintenance and service operations (i.e., garages, schools, hospitals) and 30 percent (390,000) are used in manufacturing. There are also about 16,400 open-top vapor degreasers and 8,080 conveyorized degreasers in the United States.

Most major facilities that use degreasers are located in urban and industrial areas. Between 30 percent and 40 percent of the industries using degreasers in manufacturing processes lie in the midwest corridor between Pittsburgh and the Quad Cities (Illinois/Iowa). About 12 percent to 15 percent of the national total are located in Illinois, with approximately 80 percent of the facilities located in the Chicago metropolitan area.

NATIONAL EMISSIONS ESTIMATES

Uncontrolled emissions factors for cold cleaners are 4.0 lbs/person per year, or 0.33 tons/year per unit. Open-top vapor degreasers have uncontrolled emission factors of 1.45 tons/year, 2.76 tons/year, 7.22 tons/year and 17.15 tons/year for small, medium, large and very large units, respectively. Conveyorized vapor degreasers have an uncontrolled emissions factor of 12.9 tons/year. Open-top vapor degreasers generally use nonphotochemically reactive solvents in their units (i.e., methyl chloroform, methylene chloride, perchloroethylene and CFC-113). On October 26, 1992, EPA proposed to remove perchloroethylene from the VOC list (57 FR 48490). Only trichloroethylene is photochemically reactive. In 1990, trichloroethylene accounted for 29 percent of halogenated solvent usage.

In 1990, national emissions from halogenated solvents used in degreasing were estimated at 40,700 tons/yr for trichloroethylene, 11,900 tons/yr for perchloroethylene, 8,400 tons/yr for methylene chloride and 79,600 tons/yr for 1,1,1-trichloroethane.

According to EPA (*Procedures for the Preparation of Emission Inventories for CO₂ and Precursors of O₃*), national solvent consumption for surface cleaning operations exceeds 1.7 billion pounds per year. An estimated 1.3 million cold cleaners accounted for 860 million pounds of solvent consumption. Vapor and conveyorized degreasers accounted for the remaining 870 million pounds. In this document, EPA recommends emission factors of 3.6 lbs/yr/person for cold cleaners and 0.70 lbs/yr/person for vapor and conveyorized cleaning.

AVAILABLE CONTROL STRATEGIES

EPA has already promulgated Reasonably Available Control Technology (RACT) regulations for solvent metal cleaning.

Regulations submitted to correct deficiencies in existing RACT regulations are not creditable toward meeting the 15-percent VOC reduction requirements under the Clean Air Act. There are, however, measures that go beyond RACT for which credit can be claimed. Most of these measures involve alternative cleaning techniques. Selection of an alternative technique is usually case-specific because of the many variables that must be considered. Such variables include the contaminants to be removed; the material to be cleaned; the size, shape and configuration of the part; the level of cleanliness desired; current cleaning methods; and the potential toxicity of the replacement solvent.

There are three options for control: alternative solvents, alternative cleaning processes and no-clean technologies.

Alternative Solvents: These are generally grouped into one of three categories: hydrochlorofluorocarbons (HCFCs), aqueous or semi-aqueous. Use of other organic solvents is not an alternative.

- HCFCs are typically used as replacements for chlorofluorocarbons and methyl chloroform, both of which have been banned by the Montreal Protocol and the Clean Air Act Amendments of 1990. Because neither of the banned compounds is photochemically reactive, replacing them with HCFCs earns no credit toward the 15-percent VOC reduction requirement. The same is true for methylene chloride and perchloroethylene, which are also nonphotochemically reactive. The only vapor degreasing solvent for which a credit is possible is trichloroethylene, which is photochemically reactive.
- Aqueous cleaners use water as the primary solvent and can effectively clean inorganic or polar soils, oils and greases, particles and films. In addition to water, aqueous cleaning solvents typically contain alkaline salts, surfactants and additives. Examples of alkaline salts are phosphates, hydroxides, silicates, carbonates and borates. The surfactants provide detergency, emulsification and wetting. These types of cleaners must often be heated. A survey by Wisconsin showed that the majority of 1,1,1-trichloroethane users who have substituted cleaning techniques have switched to aqueous systems; only 11 percent switched to petroleum solvents.
- Semi-aqueous cleaning solutions combine terpenes or hydrocarbons with surfactants and additional additives, such as corrosion inhibitors. Semi-aqueous cleaners can effectively remove heavy grease, tar, waxes, hard-to-remove soils and polar, as well as nonpolar, contaminants. In a semi-aqueous solution, the terpene or hydrocarbon dissolves the contaminants and the surfactant provides the wetting, emulsification and rinsing properties.

Alternative Cleaning Processes: Such processes are those that do not make use of solvents. Instead, they may involve the use of ice particles, plasma cleaning, pressurized gases, supercritical fluids, ultraviolet/ozone, mechanical processes or thermal vacuum deoiling. These processes are expensive and unproven and none are considered RACT.

No-clean Technologies: These technologies are process modifications that remove the need for degreasing or surface cleaning. Currently available no-clean technologies include controlled atmospheric soldering and the use of low-solids flux. These technologies are not considered RACT. They are very facility-specific and, thus, it would be difficult to address their use in a rule.

POTENTIAL NATIONAL EMISSIONS REDUCTION

The use of existing RACT for cold cleaners reduces emissions 55 percent to 69 percent below an uncontrolled case. For open-top vapor degreasers, RACT controls reduce emissions 45 to 75 percent. RACT controls reduce conveyORIZED emissions 50 percent to 70 percent. By using the controls described above, emissions could be reduced from the RACT control level to zero, except in the case of semi-aqueous cleaning, which still uses some organic solvents.

COST EFFECTIVENESS

Selection of an alternative technique is usually case-specific because of the many variables that must be considered. The selection of alternative solvents, alternative cleaning processes or no-clean technologies can have disadvantages, including increased space requirements; higher energy use (especially with aqueous systems); longer drying times or the need for a separate dryer; and increased waste after discharge. The South Coast Air Quality Management District (SCAQMD) reported that the cost effectiveness of its amendments for VOC emission reductions (i.e., the implementation of operational changes in existing degreasing methods, rather than the application of alternative techniques) ranges from \$92 to \$349 per ton.

FEDERAL RULEMAKING AND/OR GUIDANCE DOCUMENTS

EPA proposed a New Source Performance Standard for organic solvent cleaners in 1980 (45 FR 39766), but never finalized the regulation. As a result of a lawsuit brought against the agency, EPA signed a consent decree under which it agreed to propose a National Emission Standard for Hazardous Air Pollutants (NESHAP) by 1993 and to promulgate standards within one year of proposal. The NESHAP will control emissions of trichloroethylene, methylene chloride, perchloroethylene, methyl chloroform and CFC-113. Of these, only trichloroethylene is considered a VOC.

STAPPA/ALAPCO Recommendation

► The CTG issued in 1977 already addresses RACT for degreasing and most states have fully implemented these rules. However, with the concerns raised regarding chlorinated VOCs and stratospheric ozone damage, a number of firms are pursuing alternative aqueous or semi-aqueous cleaners or alternative cleaning processes. States may wish to pursue reductions from the larger VOC-emitting degreasing operations by exploring the potential for elimination of solvent degreasing on a case-by-case basis.

❖ *For further information on the NESHAP, contact Paul Almodovar, U.S. Environmental Protection Agency, Emission Standards Division (MD-13), Research Triangle Park, NC 27711 (telephone: 919/541-0283).*

In 1977, EPA published a CTG for controlling VOCs from degreasers (EPA-450/2-77-022). In 1989, EPA published an Alternative Control Technology (ACT) document for halogenated solvent cleaners (EPA-450/3-89-030).

STATE AND LOCAL CONTROL EFFORTS

The Lake Michigan Ozone Control Program is investigating the possibility of adopting rules beyond RACT to control VOC emissions from degreasing. Options include reducing size cutoff exemptions and controlling the volatility and/or temperature of solvents used to implement the most stringent RACT requirement.

SCAQMD amended Rule 1122, "Solvent Degreasers," in April 1991. The amendments minimized workload requirements, specified maximum draft rates and proper handling procedures for waste solvent and called for the installation of control devices. The amendments also provided more stringent equipment standards for types of covers and included specifications for freeboard ratios and refrigeration freeboard devices.

1. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. October 1, 1992. *Overview of the Halogenated Solvent Cleaning/Degreasing NESHAP*. Presented to National Air Pollution Control Techniques Advisory Committee.
2. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. *Background Information Document for Halogenated Solvent Cleaning/Degreasing NESHAP*. Draft.
3. Lake Michigan Air Directors Consortium. April 16, 1993. *Evaluation of Possible Control Measures for Solvent Metal Cleaning*. Draft.
4. South Coast Air Quality Management District. June 1991. *Staff Report for Rule 1171: Solvent Cleaning Operations*. SCAQMD No. 910626MG.
5. U.S. Environmental Protection Agency. *Procedures for the Preparation of Emission Inventories for CO₂ and Precursors of O₃*. EPA-450/4-91-016.

Summary Table – Degreasing

Affected Facilities	Cold cleaners, open-top vapor degreasers and conveyorized degreasers using photochemically reactive solvents.			
Number of Affected Facilities	Cold Cleaners: 1,300,000, 70 percent of which are used in maintenance and service operations, with the remainder used in manufacturing. Open-Top Vapor Degreasers: Small 4,100 Medium 4,930 Large 4,100 Very Large 3,290 Conveyorized Degreasers:			

^a ConveyORIZED vapor degreasing.

^b Conveyorized cold cleaning.

Glass Forming

DESCRIPTION OF SOURCE CATEGORY

Several methods are used to make glass products: the soda-lime, lead, fused-silica and borosilicate processes. The predominate one, the soda-lime process, constitutes 77 percent of total glass production. The soda-lime process uses sand, limestone, soda ash and cullet (recycled broken glass) as its principal raw materials and consists of four steps: (1) raw material preparation (blending and transport), (2) melting, (3) forming and (4) finishing. Since only the forming process emits volatile organic compounds (VOCs), it is the only step discussed in this chapter.

In forming container glass, a majority of the VOC emissions results from the contact of the red-hot, molten sphere of glass (known as a gob) with the machine lubricants used in the press and blow machines. Heat transferred from the gob to the petroleum lubricants forms a dense white cloud that can exceed 40-percent opacity. VOC emissions from other forming operations (e.g., fiberglass, flat glass) are negligible.

GEOGRAPHIC DISTRIBUTION OF SOURCES

There are approximately 100 facilities located across the nation.

NATIONAL EMISSIONS ESTIMATES

The approximately 100 glass container manufacturing facilities produced 7.6 million tons of container glass in 1991. AP-42 provides an emission factor of 8.7 pounds of VOC per ton of container glass production. Using these data, approximately 66 million pounds (33,000 tons) of VOCs are emitted nationally by container glass manufacturing.

AVAILABLE CONTROL STRATEGIES

AP-42 indicates that virtually all VOC emissions could be eliminated by substituting silicon-water emulsions for petroleum lubricants.

POTENTIAL NATIONAL EMISSIONS REDUCTION

Some container glass manufacturers have virtually eliminated VOC emissions by replacing petroleum lubricants

STAPPA/ALAPCO Recommendation

► State and local agencies should consider eliminating glass-forming VOC emissions by prohibiting petroleum-based lubricants. Plants could replace these lubricants with silicon-water emulsions.

REFERENCES

1. North Carolina Department of Environmental, Health, and Natural Resources, Division of Environmental Management. June 30, 1993. *Control Techniques Guideline for Glass Manufacturing*. Draft.
2. U.S. Environmental Protection Agency. October 1986. *Compilation of Air Pollutant Emission Factors, Volume I: Stationary Point and Area Sources*. AP-42, Fourth Edition.

with silicone emulsions. If all glass container manufacturers were to replace petroleum lubricants with silicon-water emulsions, virtually all of the VOC emissions (33,000 tons per year) could be eliminated.

FEDERAL RULEMAKING AND/OR GUIDANCE DOCUMENTS

EPA has no regulations or guidance on glass forming.

STATE AND LOCAL CONTROL EFFORTS

The South Coast Air Quality Management District's (SCAQMD's) permitting requirements for glass-forming machines limit emissions by process control. The glass-forming machines are evaluated for emissions of air contaminants, including reactive organic gases and particulate matter, which are generated from the lubricants. Any emissions increase must be offset prior to issuing a permit. The equipment must be evaluated for compliance with the following rules:

Rule	Title
401	Visible Emissions
402	Nuisance
442	Usage of Solvents
REG XIII	New Source Review

The control of emissions from glass-forming machines is accomplished through permit conditions limiting the number of times swabbing of molds is allowed. SCAQMD has not established Best Available Control Technology (BACT) for glass-forming machines.

Graphic Arts – Rotogravure and Flexographic Printing

DESCRIPTION OF SOURCE CATEGORY

The graphic arts industry includes operations related to printing newspapers, books, magazines, packages and other materials. Two basic types of printing operations are addressed in this chapter: rotogravure and flexography.

In rotogravure printing, the image area is engraved in a process called “intaglio.” The image carrier is a copper-plated steel cylinder that is etched or engraved to create wells, usually at varying depths, which provide a recessed printing area. The cylinder is rotated in an ink fountain or trough. The ink is collected in the engraved areas and removed from the nonimage areas with the use of a steel “doctor blade.” The image then is transferred directly to the substrate by pressing it against the cylinder with a rubber-covered impression roll. After each color application, the substrate is dried with either a steam drum or a hot air dryer. The temperature of the hot air dryers typically ranges from ambient temperatures to 250°F.

Flexographic printing uses a relief plate with a raised image area that transfers ink directly from the plate to the substrate. Flexography uses a rubber image carrier.

In the graphic arts industry, volatile organic compound (VOC) emissions result from the evaporation of

solvents during the drying of the ink and from solvents used during clean-up. VOC emissions in the graphic arts industry can be controlled with add-on devices, such as thermal or catalytic incineration systems or carbon adsorbers. VOC emissions can also be reduced by switching from a solvent-based ink to a waterborne ink. Radiation-curable inks, available for letterpress, lithographic and on-screen printing applications, have not been applied to rotogravure or flexographic printing operations.

GEOGRAPHIC DISTRIBUTION OF SOURCES

The graphic arts industry is included under the Standard Industrial Classification (SIC) Code 27, “Printing, Publishing, and Allied Industries.” SIC 27 includes all commercial, publishing and newspaper printing.

In the United States, there are over 60,000 facilities engaged in graphic arts, in addition to an unknown number of in-house graphic arts operations at facilities in other industries. The geographic distribution of these facilities is similar to that of the population; for instance, approximately 12 percent are located in California and 11 percent in New York.

NATIONAL EMISSIONS ESTIMATES

According to the U.S. Environmental Protection Agency's (EPA's) Control Techniques Guideline (CTG) published in 1978 for graphic arts, approximately 270,000 tons of VOCs were emitted annually from rotogravure and flexographic printing operations.

AVAILABLE CONTROL STRATEGIES

VOC emissions from rotogravure and flexographic printing operations occur from the evaporation of solvents while ink is drying. Emissions from drying ink can be controlled with add-on control devices and from the use of clean-up solvents. Some companies have successfully converted to waterborne inks; radiation-curable inks are also currently available.

Add-on Control Devices: Add-on control devices can either destroy or recover VOCs from the vent stream. For instance, add-on controls are used to control VOC emissions in the exhaust from the hot air dryers used to cure heatset inks. Typical add-on controls include thermal incinerators, catalytic incinerators and carbon adsorbers. Thermal and catalytic incinerators destroy the VOCs in the emission stream, while the carbon adsorbers recover the solvent that may be reused on site, burned or sold to a reclaimer.

Thermal incinerators burn or oxidize VOCs in the emission stream; most of the VOCs are converted to carbon dioxide and water. Thermal incinerators typically operate at temperatures up to 1600°F, requiring a residence time of 0.75 seconds. Dilute vapor streams will require that the incinerator use supplemental fuel (e.g., natural gas) to aid in combustion.

Catalytic incinerators also burn or oxidize VOCs in the emissions stream. These incinerators use a catalyst (e.g., metal oxides or precious metals that are supported on ceramic or metallic substrates) to aid in combustion. In the presence of the catalyst, VOCs can be destroyed at temperatures ranging from 660°F to 930°F, depending on the VOC concentration, catalyst activity and the required destruction efficiency. The lower operating temperature reduces the need for supplemental fuel.

Carbon adsorbers use multiple activated carbon beds to adsorb VOCs from the vapor stream. The carbon beds are operated in parallel so that when the capacity of one bed is reached, the vapor stream can be routed to another bed while the first is reactivated. Reactivation, or regeneration, is accomplished by heating the bed with steam or hot air to drive off the adsorbed organics.

Waterborne Inks: The VOC content of waterborne inks ranges from 5 to 30 percent, while solvent-based inks

have VOC contents of 50 to 85 percent. Using waterborne inks can reduce VOC emissions significantly without the need for a capture and control system. However, converting to waterborne inks may require extensive changes in equipment and operating procedures (e.g., installing higher capacity dryers, changing operating speeds and altering equipment cleaning procedures).

POTENTIAL NATIONAL EMISSIONS REDUCTION

Facilities using solvent-based inks can reduce VOC emissions by using an air pollution control system consisting of capture and destruction (or recovery) systems. The overall control efficiency of the system is calculated by multiplying the capture efficiency of the system times the destruction (or recovery) efficiency. Another alternative for facilities using solvent-based inks is to replace these inks with waterborne inks.

VOCs are captured with a permanent total enclosure (PTE), which is a structure constructed around a source of emissions so that fugitive VOC emissions are collected and vented through a stack or duct to a control device. In some cases, the room where the presses are located can serve as the PTE.

EPA has developed a set of design and operational criteria that, if met, would allow the facility to assume 100-percent capture efficiency. The criteria are as follows:

- (1) All VOC emissions must be captured and contained for discharge through a control device;
- (2) The total area of all natural draft openings (NDOs) shall not exceed 5 percent of the surface area of the enclosure's four walls, floor and ceiling;
- (3) All access doors and windows whose areas are not included in Criteria 2 and are not included in the calculation in Criteria 4 shall be closed during routine operation of the process;
- (4) The average facial velocity (FV) of air through all NDOs shall be at least 3,600 miles per hour (200 feet per minute), which equates to a pressure drop of 0.004 inches of water. [Note: Safety requirements dictate that the emission stream be at or below 25 percent of the lower explosive limit.] The direction of air through all NDOs shall be into the enclosure; and
- (5) Any NDO shall be at least four equivalent opening diameters from any VOC-emitting source.

Assuming 100-percent capture efficiency, catalytic and thermal incineration can achieve up to 98-percent VOC removal efficiency and carbon adsorbers can achieve up to 95-percent efficiency.

Additional VOC reductions are possible from clean-up operations by using low-VOC or low-vapor pressure clean-up solvents. If solvent-based inks are replaced with waterborne inks, significant reductions also will occur from using water for clean-up.

COST EFFECTIVENESS

The cost-effectiveness range for add-on control devices is summarized in Table 1. These values do not include the cost of installing a total enclosure and assume that the control devices are applied to exhaust streams operating at 10 and 25 percent of the lower explosive limit.

While converting to waterborne inks can reduce VOC emissions up to 80 percent, the cost of converting to waterborne inks is site specific; accordingly, generalized cost estimates are of little value. For more information concerning the costs associated with controlling VOC emissions in the graphic arts industry, see EPA's document *Alternate VOC Control Technique Options for Small Rotogravure and Flexography Facilities*.

FEDERAL RULEMAKING AND/OR GUIDANCE DOCUMENTS

EPA published a CTG for the graphic arts industry in December 1978. The graphic arts CTG has not been revised and it applies only to rotogravure and flexographic operations. Reasonably Available Control Technology (RACT) for the rotogravure and flexographic operations is summarized below.

Add-on control devices:

Rotogravure printing operations:

75-percent efficient (using the best available capture system)

Rotogravure packaging operations:

65-percent efficient (using the best available capture system)

Flexographic operations:

60-percent efficient (using the best available capture system)

Inks: Inks should contain less than or equal to 25 percent organic solvent by volume. However, if over 70-percent volume reduction of solvents is obtained by using waterborne inks, the complete operation is considered equivalent to the exhaust treatment systems described above. In addition, the CTG recommends that inks con-

STAPPA/ALAPCO *Recommendation*

► The existing CTG for graphic arts, published in 1978, calls for add-on control devices, which have resulted in control efficiencies between 60-75 percent. More recently, PTEs have been employed, achieving control efficiencies of greater than 95 percent. Accordingly, state and local agencies should pursue the installation of PTEs, where possible.

Agencies should also establish VOC limits for inks no less stringent than 300 grams per liter (g/l), less water and exempt solvents (2.5 lbs/gal), as these are considered reasonably available.

The use of low-solvent clean-up solutions (less than 30 percent solvent) or low-vapor-pressure clean-up solutions (less than 3 millimeters of mercury at 20°C) also represents reasonably available controls.

taining 60 percent or more of nonvolatile material be exempt from emission limitations.

In 1987, EPA accepted an emission limit of 0.5 pound of VOC per pound of solids in the ink (as applied) as an alternative emission limit that could be considered equivalent to the RACT levels recommended above. This limit applied only to flexographic and packaging rotogravure printing operations, excluding publication rotogravure applications.

On November 8, 1982, EPA promulgated New Source Performance Standards (NSPS) for the graphic arts industry (40 CFR 60, Subpart QQ) that applied to publication rotogravure printing presses constructed, modified or reconstructed after October 28, 1980. According to the NSPS, no applicable owner or operator "shall cause to be discharged into the atmosphere from any affected facility VOC equal to more than 16 percent of the total mass of VOC solvent and water used at that facility.... The water used includes only that water contained in the waterborne

raw inks and related coatings and the water added for dilution with waterborne ink systems."

EPA is also developing a National Emission Standard for Hazardous Air Pollutants (NESHAP) for the printing/publishing industry. Accordingly, EPA is currently gathering background information on the various printing applications used in the printing/publishing industry.

STATE AND LOCAL CONTROL EFFORTS

Pennsylvania regulates graphic arts systems (rotogravure and flexographic printing presses) under 25 Pennsylvania Code Section 129.66. The rule applies to facilities emitting more than 1,000 pounds of VOC per day or more than 100 tons of VOC per year. According to the rule, inks cannot contain more than 25 percent organic volatiles by volume, inks can not contain less than 60 percent solids by volume, control devices should be 90-percent effective at removing or destroying VOCs and capture systems used with the control devices should be 60- to 75-percent efficient, depending on the printing application.

Wisconsin established organic compound control requirements for the graphic arts industry under Wisconsin's Administrative Code, Section 422.14. The rule applies to packaging and publication rotogravure and flexographic printing processes and requires that inks used in these processes contain no more than 25 percent organic volatiles by volume or at least 60 percent nonvolatile material by volume (less water). However, if control devices are used instead of the ink formulations described above, the control devices must reduce VOC emissions by 90 percent (by weight). Capture systems used in conjunction with the control devices must operate at 75-percent efficiency for publication rotogravure processes, 70 percent for packaging rotogravure processes and 65 percent for flexographic printing processes.

Michigan Administrative Rule 624, which went into effect January 1, 1983, regulates existing graphic arts operations. According to Rule 624, rotogravure and flexographic printing processes cannot use inks that contain more than 25 percent organic volatiles by volume, or less than 60 percent solids. In addition, if a control device is used, the overall efficiency of the capture and control system must be at least 60 percent for flexographic printers, 65 percent for packaging rotogravure printers and 75 percent for publication rotogravure printers.

Maryland regulates graphic arts printing (rotogravure and flexographic operations) under COMAR 26.11.19.10. Maryland has the same requirements as Michigan for the graphic arts industry.

Kansas regulates both rotogravure and flexographic printing operations under Rule 28-19-71. Kansas has the

same requirements for regulating graphic arts operations as Michigan and Maryland.

Missouri regulates rotogravure and flexographic printing operations under Title 10 CSR-2:290. In general, Missouri has the same requirements as Michigan for controlling VOC emissions at rotogravure and flexographic printing facilities.

The South Coast Air Quality Management District (SCAQMD) regulates graphic art operations emitting more than 8 pounds of VOCs per day under Rule 1130. The rule limits the VOC content of various graphic arts materials (e.g., printing inks, coatings and adhesives cannot contain greater than 300 grams per liter VOC [less water and exempt compounds]). If control devices are used, they must reduce VOCs by 95 percent by weight. Collection equipment must operate at 70-percent efficiency by weight. The Bay Area Air Quality Management District and the Ventura County Air Pollution Control Division have similar regulations.

The New York City metropolitan area regulates graphic arts printing under Part 234. According to the rule, the volatile fraction of the ink (as applied) should be 25 percent or less, by volume. In addition, the ink (as applied) should contain at least 60 percent or more nonvolatile material, by volume. If control devices are used, the overall VOC reduction potential should be 75, 65 and 60 percent for publication rotogravure, packaging rotogravure and flexographic printing processes, respectively.

REFERENCES

1. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. May 5, 1993. *Background Report - AP-42 Section 4.9 Graphic Arts*.
2. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. October 1992. *Alternate VOC Control Technique Options for Small Rotogravure and Flexography Facilities*.
3. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. December 1978. *Control of Volatile Organic Emissions from Existing Stationary Sources - Volume VIII: Graphic Arts - Rotogravure and Flexography*. EPA-450/2-78-033.

4. U.S. Environmental Protection Agency. February 1991. *Best Demonstrated Technology for Graphic Arts*. EPA-450/3-91-008.
5. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. September 9, 1987. "Alternative Compliance of Graphic Arts RACT." Memorandum from D. Tyler to EPA Regions I-X.

Table 1.....
Cost Effectiveness of Control Technologies for Small Rotogravure and Flexography Facilities^a

Plant Size ^b (tons VOC/yr)	Cost Effectiveness (\$/ton VOC reduced) ^c		
	Thermal Incineration	Catalytic Incineration	Carbon Adsorption
10	\$3,500 to \$4,800	\$3,900	\$3,500
25	\$2,000 to \$3,000	\$2,500 to \$2,800	\$1,400
50	\$1,200 to \$2,400	\$960 to \$2,000	\$760 to \$780
100	\$850 to \$2,000	\$1,200 to \$1,600	\$450 to \$460
1000	\$170 to \$480	\$170 to \$350	\$120

^aSee Reference 2.

^bTotal solvent use including solvent present in purchased ink and solvent added by facility.

^c1991 dollars, exclusive of total enclosure or capture devices. Control efficiencies assumed to be 95 to 100 percent. Capture efficiencies are assumed to be 100 percent.

Table 2.....
Summary Table – Graphic Arts Rotogravure and Flexographic Printing

Affected Facilities	Rotogravure and flexographic printing facilities.
Number of Affected Facilities	In the United States, over 60,000 facilities are engaged in graphic arts, in addition to an unknown number of in-house graphic arts operations in other industries. Over 50 percent of the graphic arts industry uses lithographic printing, which is not covered by the existing CTG. In 1978, there were approximately 44,000 gravure and flexographic printing units.
National Emissions Estimates	According to the 1978 CTG for graphic arts, approximately 270,000 tons of VOC were emitted annually from rotogravure and flexographic printing operations.
VOC Emissions Range Per Facility	According to the 1978 CTG, the largest publication gravure facility employs hundreds of people and has a daily potential VOC emissions rate of 22 tons.
Cost Effectiveness	The cost effectiveness of add-on control devices ranges from \$120 to \$4,800 per ton of VOC removed. Generally, the more VOC emissions a facility emits, the more cost effective the control device. Carbon adsorbers are slightly more cost effective than incinerators. The costs to convert to waterborne coatings is site specific, therefore no generalized costs have been developed.
Federal Rulemaking and/or Guidance Documents	EPA published a CTG for the graphic arts industry in December 1978; the graphic arts CTG has not been revised since and only applies to rotogravure and flexographic operations. On November 8, 1982, an NSPS was promulgated for the graphic arts industry (40 CFR 60, Subpart QQ). The NSPS applies to publication rotogravure printing presses that were constructed, modified or reconstructed after October 28, 1980. EPA is also developing a NESHAP for the printing/publishing industry and is currently gathering background information on the various printing applications used in the printing/publishing industry, including offset lithography.
State and Local Control Efforts	Pennsylvania, Wisconsin, Michigan, Maryland, Missouri and Kansas have set regulations to control VOCs from offset lithographic printing operations. In addition, several local authorities (i.e., SCAQMD, BAAQMD, Ventura, and New York City) regulate graphic arts. In most, rotogravure and flexographic printing processes cannot use inks that contain more than 25 percent organic volatiles by volume or less than 60 percent solids. In addition, if a control device is used, the overall efficiency of the capture and control system must be at least 60 percent for flexographic printer, 65 percent for packaging rotogravure printers and 75 percent for publication rotogravure printers. The SCAQMD, the BAAQMD and Ventura have a VOC limit of 300 grams/liter for printing inks.
STAPPA/ALAPCO Recommendation	Pursue the installation of PTEs (which have achieved control efficiencies of greater than 95 percent), where possible, and establish VOC limits for inks no less stringent than 300 g/l, less water and exempt solvents (2.5 lbs/gal). The use of low-solvent clean-up solutions (less than 30-percent solvent) or low-vapor-pressure clean-up solutions (less than 3 mmHg at 20°C) also represent reasonably available controls.

Highway Paints

DESCRIPTION OF SOURCE CATEGORY

Highway paints, also referred to as traffic/maintenance paints or traffic markings, are used by state and local highway maintenance crews or contractors to mark pavement on roadways and bridges. Markings include traffic lane center lines and edge stripes, parking space markings, crosswalks, arrows, and other directional markings. Volatile organic compound (VOC) emissions occur as organic solvents in the paint evaporate during and immediately after application.

GEOGRAPHIC DISTRIBUTION OF SOURCES

Highway paints are an area source of VOCs and are used throughout the country.

NATIONAL EMISSIONS ESTIMATES

According to the U.S. Environmental Protection Agency's (EPA's) emission factors, the VOC content of typical solvent-borne highway paints is about 377 grams per liter (g/l) and 69 pounds per mile-year. Moreover, the Federal Highway Administration estimates that 37 million gallons of solvent-borne traffic paint were used in the United States

in 1988, resulting in approximately 58,000 tons of VOCs emitted from solvent-borne traffic paint that year.

AVAILABLE CONTROL STRATEGIES

Traditional containment devices or add-on controls are not applicable to this source category. Emissions of VOCs can be reduced by using lower VOC-emitting paints (i.e., "alternative markings"). Alternative markings include water-based paints, thermoplastics, preformed tapes, field-reacted materials and permanent markers. Because performance requirements vary according to the marking situation and since these materials have different physical and chemical properties, as well as a wide range of costs, different materials are suitable in different situations. Site-specific factors that must be considered when selecting alternative markings include visibility, durability, pavement type, traffic density, position of line or marking, climatic restrictions, drying or setting time, safety of material and application procedure, difficulty of application and equipment availability.

Table 1 compares the advantages and disadvantages of various alternative marking materials. In all cases, using alternatives to solvent-based paints reduces emissions of

VOCs, as well as toxic air pollution, and reduces storage and handling of hazardous materials. Since much of the paint purchased for this category is used or specified by state and local highway departments and is subject to an open bid process or contract specifications, it may be necessary to coordinate with these agencies, particularly where additional application equipment will be required.

POTENTIAL NATIONAL EMISSIONS REDUCTION

The regulation of highway paints offers significant potential in reducing VOCs, representing one of the largest categories of architectural and industrial maintenance (AIM) coatings. If California's "suggested control measure" of 250 g/l were required nationwide, for example, VOC emissions could be reduced by over 27,000 tons per year.

The Lake Michigan Ozone Control Program has estimated that adoption by Illinois of a rule limiting the VOC content of highway paints to 250 g/l could reduce VOC emissions by almost 40 percent for this source category.

COST EFFECTIVENESS

Assuming that solvent-based and water-based coatings have unit costs of \$5/gallon and \$6/gallon, respectively, or less, and that water-based coatings last 25 percent longer than solvent-based coatings, a reduction in the VOC content of traffic markings to 250 g/l could result in a net savings of \$1,462 per ton of VOCs reduced.

FEDERAL RULEMAKING AND/OR GUIDANCE DOCUMENTS

Highway paints are one of the categories included in EPA's regulatory development for AIM coatings. The AIM regulation is being developed through a regulatory negotiation, including representatives from industry, users, environmental organizations and state and local agencies (including STAPPA and ALAPCO).

❖ *For more information, contact Jim Berry, U.S. Environmental Protection Agency, Emission Standards Division (MD-13), Research Triangle Park, NC 27711 (telephone: 919/541-5605).*

STATE AND LOCAL CONTROL EFFORTS

The California Air Resources Board (CARB) developed a model rule for architectural coatings that also regulates traffic paints. The model rule, developed in 1977 and revised in 1989, prohibits the sale, or manufacture for sale,

STAPPA/ALAPCO Recommendation

► State and local agencies should set VOC content limits for highway paints no less stringent than 250 g/l, since several jurisdictions – California, New York, New Jersey and Arizona – are already meeting that level. If areas are seeking additional emission reductions, they should consider adopting a limit of 150 g/l, as it would allow the use of waterborne coatings, epoxies and thermoplastics. Air pollution control agencies should coordinate with their Departments of Transportation since the lower limits may require a conversion of application equipment to accommodate waterborne coatings in areas currently using solventborne coatings.

of any traffic paint containing more than 250 g/l of VOCs. Sixteen of California's 34 local air districts have similar architectural coating rules or have adopted the CARB model rule.

The South Coast Air Quality Management District (SCAQMD) is one of the 16 California districts that has adopted the CARB model rule. Rule 1113, "Architectural Coatings," limits the VOC content of traffic paints for public streets and highways to 250 g/l of coating, less water and exempt compounds. Highway paint striping equipment does not require a permit; therefore, Best Available Control Technology (BACT) is not applicable. The 1991 Air Quality Management Plan Tier I Control Measure A-A-1, "Architectural Coatings," encourages coating reformulation to reduce VOC emissions from all architectural coatings, but does not specifically target highway striping. Tiers II and III do not have strategies specific to highway coatings.

New Jersey, Arizona and New York have also developed architectural coating rules that limit the VOC content of traffic paints to 250 g/l.

Other states, including Virginia and Wisconsin, have been using highway paints with VOC concentrations

approximating 120 g/l. Wisconsin is currently considering a rule that would limit the VOC content of highway paints to 91 g/l.

REFERENCES

1. U.S. Department of Commerce, Bureau of the Census. January, 1990. *1987 Census of Manufacturers – Paints and Allied Products, Industry 2851*. Publication No. MC87-1-28E.
2. U.S. Environmental Protection Agency, Control Technology Center. October 1988. *Reduction of Volatile Organic Compound Emissions from the Application of Traffic Markings*. EPA-450/3-88-007.
3. Lake Michigan Air Directors Consortium. April 16, 1993. *Control of Emissions from Traffic/Maintenance Painting*. Draft.

Table 1.....

Alternative Marking Materials: Advantages and Disadvantages

Marking Material	Advantages	Disadvantages
Solventborne paints	Low initial cost Good dry-night visibility Short drying times available Well-established technology No pavement-type limits	High VOC emissions Short life Poor wet-night visibility
Waterborne paints	Low VOC emissions Low initial cost Good dry-night visibility Good equipment availability Easy to adapt from solvent-based paints Easy cleanup No pavement-type limits	Poor wet-night visibility Short life Weather restrictions Application and storage equipment must be made or coated with rust-resistant materials More heat sensitive Must be stored at controlled temperatures to prevent freezing
Thermoplastics	Negligible VOC emissions Long life Good night visibility (wet or dry) 100 percent solids	High initial cost High application temperature Reduced durability on Portland cement concrete More difficult application than for paint
Preformed tapes	No VOC emissions if adhesion primer is not needed Long life Little or no application equipment needed Excellent material safety 100 percent solids	High VOC emissions if adhesion primer is needed Very high initial cost Variable night visibility
Field-reacted materials	Negligible VOC emissions Long life Moderate initial cost Virtually 100 percent solids Good night visibility	Polyester type adheres poorly to Portland cement concrete Special application equipment needed
Permanent markers	Negligible VOC emissions Long life Excellent night visibility (wet or dry)	High initial cost Poor durability in snow-plowed areas

HIGHWAY PAINTS

Table 2
Summary Table – Highway Paints

Affected Facilities	State departments of transportation and/or contractors working for states.					
Number of Affected Facilities	In 1989, approximately 58,000 tons of highway paints were used throughout the country.					
National Emissions Estimates (pounds VOC/mile-year)	Solvent 69	Water 13	Thermoplastics Neg.	Field Reacted Neg. ^a 0.25 ^b	Preformed Marker 0 ^c 58 ^d	Permanent 0
Potential National Emissions Reduction	40-percent reduction in VOCs.					
Cost Effectiveness	Net savings of \$1,462 per ton of VOCs reduced.					
Federal Rulemaking and/or Guidance Documents	EPA is developing regulations as part of a regulatory negotiation for AIM coatings, of which highway paints are a part. The negotiation is expected to conclude in the summer of 1993.					
State and Local Control Efforts	Sixteen of California's 34 districts, as well as New York, Arizona and New Jersey, have adopted architectural surface coating regulations limiting VOC content of highway paints to 250 g/l.					
STAPPA/ALAPCO Recommendation	Set VOC content limits no less stringent than 250 g/l; consider a limit of 150 g/l.					

^a Polyester

^b Epoxy

^c Without adhesive primer

^d With adhesive primer

Industrial Wastewater Treatment

DESCRIPTION OF SOURCE CATEGORY

Industrial wastewaters are generated by a wide range of production and manufacturing industries. Industrial groups that would be covered under the U.S. Environmental Protection Agency's (EPA's) draft federal Control Techniques Guideline (CTG) are:

- the organic chemicals, plastics and synthetic fibers industry (OCPSF);
- the pesticide industry;
- the pharmaceuticals industry; and
- hazardous waste treatment, storage and disposal facilities (TSDFs).

Volatile organic compound (VOC) emissions can occur both when industrial wastewaters are transported (in sewer systems and at pumping stations) and treated to remove contaminants prior to final discharge. Potential emission sources include collection systems (e.g., drains, manholes, junction boxes, lift stations, trenches, sumps); VOC removal processes (e.g., air stripping, steam stripping); preliminary treatment and flow measurement devices (e.g., flow equalization basins, screens, grit

removal, Parschall flumes); primary treatment units (e.g., settling tanks, dissolved air flotation); secondary treatment units, including both chemical/physical and biological treatment units (e.g., aeration tanks, biological contactors, aerated lagoons); settling basins and secondary clarifiers; filtration systems (e.g., sand filters, mixed-media filters, carbon beds); and chemical storage tanks.

Emissions vary according to the type of treatment process or operation; the amount of turbulence associated with flow into, through or out of the unit; the surface area of exposed wastewaters; and whether or not the treatment unit is heated, aerated or covered.

In addition to the liquid waste treatment unit operations and processes, other associated activities may cause VOC emissions. Such activities include chemical storage; residuals management (i.e., sludge dewatering, sludge pumping/transport, sludge disposal, carbon regeneration); and effluent aeration that may be required to meet water pollution discharge limits or municipal discharge limits.

GEOGRAPHIC DISTRIBUTION OF SOURCES

Industrial wastewater treatment facilities are located throughout the United States. The following list, included

in EPA's draft CTG, provides a distribution of industrial wastewater treatment facilities.

Wastewater Generation by Industry

Industry	Total Number of Facilities (1982)
OCPSF	1,000
Pesticides manufacturing	119
Pharmaceutical manufacturing	466
Hazardous waste TSD	1,909
TOTAL	3,494

NATIONAL EMISSIONS ESTIMATES

EPA estimates total VOC emissions from the four industrial groups at 278,000 megagrams per year (Mg/year) (308,580 tons/year). These emissions are generated by 8,100 wastewater streams flowing at a combined rate of 563,000 liters/minute (lpm) (214 million gal/day).

AVAILABLE CONTROL STRATEGIES

Several VOC control strategies are available for industrial wastewater treatment facilities. The first strategy is to minimize the amount of VOCs in wastewater streams through changes in raw materials used, modification of processes and operating practices, preventive maintenance, recycling or segregation of waste streams. This strategy includes reducing the VOC content of the wastewater through product substitution or treatment before the stream contacts ambient air. A second approach is to employ VOC capture and control strategies at the wastewater treatment facilities.

A complete strategy for reducing the VOC emissions from industrial wastewater facilities would include consideration of each of the above elements, as well as the following steps:

- suppression of emissions from collection and treatment system components by enclosing the existing wastewater collection system from the point of generation to the point of treatment;
- treatment of the wastewater to remove organic compounds; and
- treatment of residuals, including oil phases, condensates and sludges from nondestructive treatment units.

STAPPA/ALAPCO Recommendation

► For industrial wastewater streams, agencies should consider regulations that enclose the wastewater stream to the point of treatment and require 95-percent control of volatiles or to 20 ppmw. EPA's draft CTG applies to industrial wastewater streams with a minimum VOC concentration of 500 ppmw and a flow rate of 1 liter per minute. Agencies should consider applying regulations to lower concentration streams (e.g., 250 ppmw).

POTENTIAL NATIONAL EMISSIONS REDUCTION

According to EPA estimates, potential VOC emissions reductions range from 232,000 Mg/yr (257,520 tons/yr) to 255,000 Mg/yr (283,050 tons/yr), depending on the final level of control. This corresponds to a potential emissions reduction of 83 percent to 92 percent.

COST EFFECTIVENESS

The national cost effectiveness ranges from \$430/Mg (\$387/ton) to \$1,500/Mg (\$1,351/ton). Table 1 presents cost effectiveness data for the proposed national Reasonably Available Control Technology (RACT) options.

FEDERAL RULEMAKING AND/OR GUIDANCE DOCUMENTS

In November 1992, EPA submitted a preliminary draft Control Techniques Guideline (CTG) for industrial wastewater to the Office of Management and Budget, where it is currently under review. As of July 1993, the agency had not issued a final draft document for this source category. Under the proposal, industrial wastewater containing hazardous waste and exceeding 500 parts per million weight (ppmw) would be regulated under a proposed rule for hazardous waste treatment, storage and disposal facilities (56 FR 33490, July 22, 1991).

Industrial wastewater will also be regulated by the Hazardous Organic National Emission Standard for Haz-

ardous Air Pollutants (HON) proposed by EPA in December 1992 (57 FR 62616). As proposed, the HON would place control requirements on air emissions for all wastewater streams with a hazardous air pollutant concentration of 5 ppmw or greater and a flow rate of 0.02 liters per minute or greater. The proposed wastewater provisions include detailed flow charts to assist in determining applicability and control requirements.

❖ *For further information on EPA's CTG, contact Elaine Manning, U.S. Environmental Protection Agency, Emissions Standard Division (MD-13), Research Triangle Park, NC 27711 (telephone: 919/541-5499).*

STATE AND LOCAL CONTROL EFFORTS

The Lake Michigan Ozone Control Program provided information on controlling VOC emissions from industrial wastewater treatment facilities in Indiana, Illinois and Wisconsin. None of these states regulates surface impoundment facilities. Storage tanks with capacities greater than 150,000 liters (39,000 gallons) containing liquids with a true vapor pressure of greater than 10.5 kilopascals (kPa) (1.52 pounds per square inch) are subject to Indiana rules under Title 326 IAC Article 8-4. New VOC removal devices with the potential to emit greater than 25 tons per year are subject to Best Available Control Technology (BACT) requirements under 326 IAC 8-1-6. RACT is also applied to refinery wastewater separators in Indiana.

In Illinois, storage tanks are regulated under Section 218.121 of Illinois Rules and Regulations. Part 219.443 of the same law covers emissions from petroleum refinery oil and water separators, requiring an 85-percent control efficiency.

The South Coast Air Quality Management District (SCAQMD) evaluates industrial wastewater treatment facilities on an individual basis to determine if there are VOC emissions or toxic compounds that may have an effect on the local environment. If it is determined that emissions are greater than allowed, then the capture and control of these emissions is required. Conventional air pollution control equipment is used for the control of VOCs and toxics. These control methods make use of activated carbon, thermal oxidation, chemical oxidation, biofiltration or other similar techniques. Tests are conducted to verify that the control equipment is operating according to the permitted levels.

REFERENCES

1. Lake Michigan Air Directors Consortium. April 1993. *Evaluation of Possible Control Measures for Control of Emissions From Industrial Wastewater Treatment Facilities [VOC]*. Draft.
2. U.S. Environmental Protection Agency. April 20, 1989. *Reasonably Available Control Technology Options for the Industrial Wastewater*. Draft Control Techniques Guideline Document.
3. U.S. Environmental Protection Agency. December 31, 1992. *National Emission Standards for Hazardous Air Pollutants for Source Categories; Organic Hazardous Air Pollutants from the Synthetic Organic Chemical Manufacturing Industry and Seven Other Processes*. Proposed Rule and Notice of Public Hearing. 57 *Federal Register* 62608.

INDUSTRIAL WASTEWATER TREATMENT

Table 1.....

Total Industry RACT National Impacts^{a,b}

RACT Option Description			VOC Emission Reduction (Mg/yr)	Percent VOC Emission Reduction	Total National Capital Cost (\$MM)	Total National Annual Cost (\$MM/yr)	National Cost Effectiveness (\$/Mg)	Incremental Cost Effectiveness (\$/Mg)
VO Concentration Cutoff (ppmw)	Flow Rate Cutoff (lpm)	Maximum VO Concentration (ppmw)						
1,000	10	10,000	232,000	83%	190	100	430	
500	1	10,000	244,000	88%	240	120	480	1,400
200	1	10,000	251,000	90%	300	150	610	5,700
100	1	10,000	252,000	91%	330	170	690	13,800
TIC			255,000	92%	600	380	1,500	65,900

^a See Reference 2.

^b All options include a maximum VO concentration cutoff of 10,000 ppmw

Baseline VOC emissions = 278,000 Mg/yr

Total Wastewater Volume = 563,000 lpm

Total Number Wastewater Streams = 8,100

TIC = Total Industry Control

Table 2.....

Summary Table – Industrial Wastewater Treatment

Affected Facilities	Facilities with wastewater streams that have a minimum volatile organic concentration of 500 ppmv and a flow rate of 1 liter per minute.
Number of Affected Facilities	Approximately 3,500 facilities nationwide.
National Emissions Estimates	278,000 Mg/yr of VOCs.
100 TPY Source Size	Average emissions are 88 tons per year, per facility.
Potential Emissions Reduction Per Facility	83 to 92 percent of VOCs.
Cost Effectiveness	\$430/Mg (\$387/ton) to \$1,500/Mg (\$1,351/ton).
Federal Rulemaking and/or Guidance Documents	HON promulgation expected in 1994. Final CTG expected in 1994.
State and Local Control Efforts	<p>SCAQMD - Industrial wastewater treatment facilities are evaluated on an individual basis to determine if there are VOC emissions or toxic compounds that may have an effect on the local environment. If it is determined that emissions are greater than allowed, then the capture and control of these emissions is required. Conventional air pollution control equipment is used for the control of VOCs and toxics. These control methods make use of activated carbon, thermal oxidation, chemical oxidation, biofiltration or other similar techniques. Tests are conducted to verify that the control equipment is operating according to the permitted levels.</p> <p>Indiana - Storage tanks greater than 150,000 liters with greater than 10.5 kPa vapor pressure liquids are regulated. VOC removal devices with potential to emit greater than 25 tons per year are subject to BACT. RACT is applied to refinery wastewater separators.</p> <p>Illinois - Storage tanks and refinery separators are regulated.</p>
STAPPA/ALAPCO Recommendation	Enclose wastewater stream to point of treatment and require 95-percent control of volatiles or to 20 ppmw; consider applying to lower VOC concentration streams (e.g., 250 ppmw).

Iron and Steel Foundries

DESCRIPTION OF SOURCE CATEGORY

Operations within a typical iron and steel foundry involve mold preparation, metal melting, metal pouring and casting treatment. Mold preparation includes mixing sand and binder, fabricating molds, core making and bake out. Melting operations include charging metal scrap, fluxes and coke into furnaces and melting the charge. Metal pouring involves discharging melted metal into a ladle, transferring the ladle to a pouring area and pouring melted metal into assembled molds. Molds are moved to a holding area for cooling and then to a casting shakeout station, where the sand is removed from the castings by vibration. Cleaned castings undergo additional cooling and may then be subject to finishing operations including surface cutting and machining, hot oil annealing and applications of protective coatings.

Most of the volatile organic compound (VOC) emissions from the iron and steel foundry industry come from scrap melting operations and casting shakeout. According to the U.S. Environmental Protection Agency (EPA), approximately 77 percent of all VOC emissions are attributable to casting shakeout of chemically-bound molds. Additional VOC emissions sources are associated

with metal pouring, filled-mold cooling, casting treatment and finishing and mold fabrication.

VOC emissions during metal melting vary in concentration depending upon the amount of organic contamination on the scrap. Pouring and cooling operations are a significant source of VOC emissions; maximum emissions occur one to six minutes after pouring begins. However, most of the gases are formed at the interface between the sand and the metal inside the mold. Since these VOC gases must pass through the sand to escape, they become trapped within the sand of the mold. Organics with higher molecular weight are trapped close to the sand/metal interface, while organics with a lower molecular weight are further away from this interface in the cooler regions of sand.

Of the many foundry operations, shakeout has the potential to generate the most VOC emissions. Most of the thermal decomposition of the mold/core materials has occurred by the time the mold assembly reaches the shakeout. Since products of thermal decomposition tend to be organics with lower molecular weight, they vaporize and defuse away from the hot metal-sand interface. Some of the organic vapors condense and adsorb on the cooler sand in the mold. Most organic compounds with boiling points below 212°F are lost during mold cooling. During shake-

out, flash vaporization occurs. Additionally, following shakeout, emissions continue to occur due to the exposure of the warm sand to cool ambient air, as well as the mixing of cooler sand with hot sand.

Cleaning and finishing are variable in foundry operations, since they are highly dependent on product specifications. EPA has reported no VOC emissions from cleaning and 1.1 lbs VOC/ton of metal processed from finishing, although cleaning and finishing emissions from three-dimensional machining operations using oil cooling sprays may be significant.

A major step used in steel foundry operations is inoculation, which allows steel alloys to be created. The primary emission during inoculation is particulate matter, rather than VOCs.

Finally, in that steel foundries generally operate at temperatures 650°F to 750°F higher than iron foundries, VOC emissions will be higher in comparison.

GEOGRAPHIC DISTRIBUTION OF SOURCES

Foundries are operated in all 50 States. Most are concentrated in California, Illinois, Michigan, Ohio, Pennsylvania and Wisconsin.

NATIONAL EMISSIONS ESTIMATES

The VOC emission factor for casting knockout is 1.2 lbs VOC/ton of sand processed.

AVAILABLE CONTROL STRATEGIES

Several modifications in foundry operating practices may yield substantial VOC emissions reductions. VOC emissions from casting shakeout operations are highly dependent on the types of cores manufactured, coatings and washes used on cores, mold size and cooling time.

The manufacture of cores involves the use of one of three general binder types: thermal activated or hot-box, no-bakes and cold-box. Thermal activated binders are mixed with sand and heated to 400°F to 500°F in order to catalyze the binder reaction. No-bake binders are two- or three-part systems that are activated by the addition of a catalyst. Cold-box binders are one of two-part systems that use an organic gas (such as triethylamine or dimethylethylamine) to catalyze the polymerization reactions. Because of production restrictions and the chemistry of products, cold-box systems generally allow a higher core production rate and are used by the larger, high-production foundries. According to the Lake Michigan Ozone Control Program, cold-box systems account for 90 percent of all core binder emissions. VOC emissions can be reduced by substituting

STAPPA/ALAPCO *Recommendation*

► State and local agencies should consider adopting a rule similar to the SCAQMD's, which requires combustion gas to be exhausted in a manner that limits the discharge of carbon monoxide to 2000 ppm by volume or less.

hot-box and no-bake cores for cold-bake cores.

Cores are often washed or coated with a refractory layer. These coatings or washes also come in three basic types: VOC-based (usually isopropanol), exempt solvent-based (i.e., methylene chloride or methyl chloroform) or water-based. The purpose of coatings and washes is to alter the surface of the core to improve casting manufacture. VOC emissions can be reduced by using non-VOC-based core coatings. Both methylene chloride and methyl chloroform are hazardous air pollutants (HAPs); thus, no advantage would be gained by substituting HAP-based cores for VOC-based cores.

Mold size and cooling time affect the temperature distribution within the sand mold at the time of casting shakeout. The higher the maximum temperature and the wider the temperature distribution in the mold at the time of shakeout, the higher the VOC emissions generated. Therefore, significant reductions in VOC emissions during casting shakeout may be achieved by merely increasing the cooling time for the molds, with virtually no VOC emissions resulting if the mold and metal castings are cooled to ambient conditions before shakeout. However, the increased cooling time would increase the residual organics on the sand that is recycled for mold fabrication, the production time would increase because of the additional cooling time required and VOC emissions would increase during pouring. Thus, the benefits achieved by allowing the mold to cool are marginal. In addition, because increased cooling time can affect casting properties, it may be difficult for many foundries to use this control strategy.

Another way to reduce VOC emissions is by using add-on controls. VOC emissions from gassing of no-bake cores may be controlled with a reactive scrubber. These controls currently are used by most foundries to reduce

malodorous emissions. The control efficiency reported by the Lake Michigan Ozone Control Program is greater than 90 percent.

Reductions in VOC emissions from scrap melting are possible through a procedural modification, such as metal scrap segregation by organic contaminant content. Higher organic contaminated scrap would be used in cupola furnaces where organic combustion occurs. Use of new cupola furnace designs and operating procedures, such as hot air injections, oxygen enrichment and gas fired cupolas, would increase. The new designs provide increased combustion of organics and allow reduced use of coke, which is also a source of VOC emissions.

Secondary combustion for cupolas also can be used as a control strategy. This process refers to the "secondary" combustion of the products of combustion emitted from a cupola and is accomplished by installing a "hot-top" burner in the cupola itself or ducting the cupola gases to an afterburner.

Another available control strategy is to clean the scrap metal prior to charging it into the furnace. Options available are steam cleaning, inorganic washing and use of a burn-off furnace.

FEDERAL RULEMAKING AND/OR GUIDANCE DOCUMENTS

EPA has not promulgated rules or guidance regarding VOC emissions from iron and steel foundries.

STATE AND LOCAL CONTROL EFFORTS

The South Coast Air Quality Management District (SCAQMD) requires combustion gases to be exhausted in a manner that limits the discharge of carbon monoxide to 2000 parts per million (ppm) by volume or less. Since secondary combustion temperatures are required to be above 1400°F to provide for oxidation of the carbon monoxide, the VOCs present in the exhaust gases are also combusted.

REFERENCES

1. U.S. Environmental Protection Agency, Office of Environmental Engineering and Technology. January 1984. *Organic Emissions from Ferrous Metallurgical Industries: Compilation of Emission Factors and Control Technologies*. EPA-600/2-84-003.
2. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. March 1990. *AIRS Facility Subsystem Source Classification Codes and Emission Factor Listing for Criteria Air Pollutants*. EPA-450/4-90-003.
3. Lake Michigan Air Directors Consortium. April 16, 1993. *Control of Emission from Non-CTG RACT Sources in Wisconsin - Iron and Steel Foundries*. Draft.

Iron and Steel Industry/Sinter Plants

DESCRIPTION OF SOURCE CATEGORY

Sinter plants, which are usually part of integrated iron and steel plants, are facilities that agglomerate (create a fused mass) large amounts of blast furnace dust and other iron-bearing fines into hard clinkers suitable for use in blast furnaces. The process is capable of converting a wide variety of fines (i.e., iron-bearing furnace dust and sludge, mill scale, steelmaking dust and iron-bearing dust and sludge collected from air and water pollution control processes) into a high-quality furnace burden material. The secondary function of sintering is to calcine part or all of the flux material for the iron-making process. Most volatile organic compound (VOC) emissions from sinter plants are a result of oil and grease contamination on mill scale. Although most of the oils and grease on the mill scale are burned during the sintering process, vaporization of some hydrocarbons takes place in the preheating zone below the flame front. Vaporized hydrocarbons become a part of windbox gases.

The sintering process is comprised of the following devices: a material storage, blending and feeding system for the burden material; a traveling-grate hearth, called the sinter strand, to produce the sinter; and a sinter breaking,

screening and cooling system to size and cool the sinter properly. The feed to the sinter strand consists of raw materials from the blending pile (i.e., ores and other materials that have been blended into a homogeneous mixture), fluxes, solid fuels (usually coke breeze) and recycled sinter fines. This mix travels under an ignition hood where hot combustion gases ignite the solid fuel contained in the sinter mix.

The sinter process starts when the solid fuel in the sinter mix ignites. Air is pulled downward through the bed and into windboxes under the traveling grate. The raw materials are thermally fused into a hard clinker material. All of the combustion products, excess air and other gaseous materials exiting the sinter box during the sinter process are captured in the windboxes under the sinter strand. The hard clinker material is broken and fed through screens and crushers to be properly sized.

GEOGRAPHIC DISTRIBUTION OF SOURCES

Sinter plants are typically a part of integrated iron and steel plants, although some plants have eliminated sintering. In 1981, there were 20 integrated steel companies operating 42 plants, which were concentrated in Illinois, Indiana,

STAPPA/ALAPCO Recommendation

► State and local agencies should consider imposing deoiling controls to levels no less stringent than 1 percent oil and grease for mill scale.

Michigan, Ohio and Pennsylvania. In 1989, there were 15 integrated plants. The distribution of sinter plants is assumed to correspond to the distribution of integrated iron and steel plants.

NATIONAL EMISSIONS ESTIMATES

It is estimated that in 1981, sinter plants were responsible for 69,500 tons of VOC emissions nationally.

AVAILABLE CONTROL STRATEGIES

Most VOC emissions at sinter plants result from vaporization and incomplete combustion of oil and grease contamination on mill scale, coke and sludge. The first strategy for reducing VOC emissions is to minimize the oil and grease in the raw materials. A second approach is to install add-on pollution control systems, such as incinerators, carbon adsorbers or condensers on the exhaust stream from the windboxes.

POTENTIAL NATIONAL EMISSIONS REDUCTION

The Lake Michigan Ozone Control Program study included a survey to establish the amount of oil and grease contamination normally found on mill scale as a percentage of total weight. The amounts of organic compounds in coke and sludge were not a part of the survey. The results indicated that the oil and grease content of mill scale varies between 3 percent and 4 percent. One of the plants included in the study de-oiled mill scale before sintering to accommodate operating limitations of its baghouse. The plant operated an unspecified de-oiling system, the cost of which was not provided. Reportedly, the oil and grease content of mill scale can be reduced to 1 percent. A reduction of oil and grease from 4 percent to 1 percent or less

would result in a 75-percent reduction in the VOC emissions related to hydrocarbon contamination on mill scale.

Add-on control devices, such as incinerators, carbon adsorbers or condensers, may reduce the VOC emissions by more than 98 percent, assuming 100-percent capture efficiency. However, since there is no known experience related to add-on controls for VOC emissions from sintering, their applicability to this process is uncertain.

Using the VOC emissions estimate for 1981 and assuming a control efficiency of 98 percent, the potential national VOC emission reduction would be 68,100 tons/year.

COST EFFECTIVENESS

The Lake Michigan Ozone Control Program study calculated the cost effectiveness of using add-on control equipment as \$944/ton of VOC removed. This calculation assumed VOC emissions of 11.5 tons per day, a 50-percent heat recovery and a control efficiency of 98 percent. However, the capital costs of incineration associated with an airflow rate of approximately 450,000 standard cubic feet per minute are not within the parameters included in the Cost Control Manual published by EPA in 1990. In addition, operating conditions may vary enough to result in cost estimates that are incorrect by several orders of magnitude.

Cost effectiveness has not been calculated for the reduction of oil contamination on mill scale prior to entering it in the raw material mix in a sinter plant. Further study is necessary to evaluate the cost effectiveness of two potential methods of reducing VOC emissions from sintering plants: 1) evaluating mill scale waste streams for contamination and discontinuing the use of highly contaminated waste. However, although this type of selection process could reduce VOC emissions, it could create a landfill problem; and 2) removing oils from mill scale prior to incorporation into the mix by using heated air to vaporize the oils for capture or destruction. (Equipment for such a system could consist of a fluidized bed, baghouse and catalytic incinerator)

The minimization of oil contamination on mill scale prior to incorporating it into the sinter plant material flow may be the most cost-effective means for controlling VOC emissions from sinter plants.

FEDERAL RULEMAKING AND/OR GUIDANCE DOCUMENTS

EPA has not published guidance for controlling VOCs from this category.

STATE AND LOCAL CONTROL EFFORTS

State and local agencies generally have not regulated VOC emissions from sinter plants.

REFERENCES

1. Air and Waste Management Association, 1992. *Air Pollution Engineering Manual*. New York: Van Nostrand Reinhold.
2. U.S. Department of the Interior, Bureau of Mines. 1991. *1989 Minerals Yearbook*. Washington: U.S. Government Printing Office.
3. U.S. Environmental Protection Agency, Office of Research and Development. January 1984. *Organic Emissions from Ferrous Metallurgical Industries: Compilation of Emission Factors and Control Technologies*. EPA-600/2-84-003.
4. Lake Michigan Air Directors Consortium. April 1993. *Control of Emissions from Non-CTG RACT Sources in Indiana-Sinter Plants*. Draft.
5. U.S. Environmental Protection Agency, Office of Research and Development. September 1982. *Organic Emissions from Iron Ore Sintering Plants - Determination of Causes and Methods of Abatement*. EPA-600/2-82-91.

Table 1.....**Summary Table – Iron and Steel Industry/Sinter Plants**

Affected Facilities	Sinter plants.
Number of Affected Facilities	An estimated 15 or more affected facilities.
National Emissions Estimates	Information available for 1981 estimated 69,500 tons of VOC emissions nationwide.
VOC Emissions Range Per Facility	The VOC emissions range for a facility is not available. However, annual VOC emissions for a sinter plant are estimated to be 4,800 tons in an integrated steel mill producing 3,000,000 tons of finished steel per year.
100 TPY Source Size	A 100-ton/yr source would process 160,000 tons of sinter per year (1.25 lbs VOC/ton sinter).
Potential Emissions Reduction Per Facility	Using the 4,800-ton/yr VOC emissions estimate and the 98-percent control efficiency estimate, the potential VOC reduction per facility would be 4,700 tons/yr.
Cost Effectiveness	Estimates indicated a cost effectiveness of \$944 per ton of VOC emissions controlled.
Federal Rulemaking and/or Guidance Documents	EPA has not published rules or guidance applicable to sinter plants.
State and Local Control Efforts	No state or local rules require VOC emission control for sinter plants.
STAPPA/ALAPCO Recommendation	Require deoiling controls to levels no less stringent than 1 percent oil and grease for mill scale.

Landfill Gases

DESCRIPTION OF SOURCE CATEGORY

Landfill gas is generated naturally by the aerobic and anaerobic decomposition of waste. Such gas consists primarily of methane and carbon dioxide, with volatile organic compounds (VOCs) making up less than 1 percent of emissions. While this amount may seem small, VOC emissions from landfills approximated 255,000 megagrams (Mg), or 283,000 tons, in 1992.

Waste arriving at a landfill is placed in open cells, where some VOCs are emitted to the ambient air. Although soil covers are used to control emissions, VOCs continue to escape into the air even after a cell is closed.

GEOGRAPHIC DISTRIBUTION OF SOURCES

There were approximately 6,000 active landfills in the United States in 1987. In addition, the U.S. Environmental Protection Agency (EPA) estimates that there are more than 32,000 closed solid waste disposal facilities across the country.

NATIONAL EMISSIONS ESTIMATES

As noted above, EPA estimates that VOC emissions from both active landfills and those closed after November 8, 1987 totaled approximately 255,000 Mg (283,000 tons) in 1992. Municipal solid waste landfills account for about 1 percent of the VOC emissions from stationary sources nationwide. Methane emissions from municipal solid waste landfills total approximately 10.4 million Mg/yr (12 million tons/yr). By 1997, VOC emissions are expected to increase to 506,000 Mg/yr (557,000 tons/yr) and methane emissions are expected to reach 18.1 million Mg/yr (19.9 million tons/yr).

AVAILABLE CONTROL STRATEGIES

The only available control strategy for reducing landfill gas emissions is a well-designed and well-operated gas collection system with a control device capable of reducing VOCs in the collected gas by at least 98 weight-percent. The control device included as part of Best Demonstrated Technology (BDT) is an open flare capable of reducing VOC emissions by at least 98 weight-percent. Open flares are applicable to all affected and designated facilities that

would be regulated under EPA's proposed emissions standards and guidelines.

A well-designed and well-operated collection system would, at a minimum:

- be capable of handling the maximum gas generation rate;
- allow for monitoring of landfill gas and adjustment of the gas collection system;
- collect gas effectively from all areas of the landfill that require control; and
- be expandable to new areas of the landfill that require control.

Energy recovery systems have also been demonstrated to achieve 98-percent emission control at landfills where their use is feasible. Energy recovery systems used to combust landfill emissions include internal combustion engines, gas turbines and steam-generating boilers. Power produced by these systems may be used for heating or to generate electricity.

POTENTIAL NATIONAL EMISSIONS REDUCTION

EPA estimates that its proposed guidelines for existing landfills will reduce VOC emissions by 404,000 Mg/yr (448,000 tons/yr) in 1997, a 79-percent reduction from the projected 1997 baseline level. The guidelines are also expected to reduce methane emissions from existing landfills by 9.6 million Mg/yr (10.5 million tons/yr). As existing landfills are filled, closed and replaced by new landfills, the emissions reductions achieved by the proposed EPA guidelines will decrease, while the reductions achieved by the proposed standards will rise proportionately.

Meanwhile, the agency estimates that proposed standards for new landfills will reduce VOC emissions by 4,080 Mg/yr (4,510 tons/yr) from the 940 new landfills expected to be built by 1997. This would represent a 44-percent reduction from a baseline emissions level of 9,250 Mg/yr (10,200 tons/yr). The proposed standards are also expected to reduce methane emissions from new landfills by 87,800 Mg/yr (96,700 tons/yr) from a baseline level of 471,000 Mg/yr (519,000 tons/yr).

The emissions reduction potential of new and existing landfills, expressed as a percentage of the baseline emissions, is summarized below. Although gas collection system capture efficiencies can range from 50 percent to over 90 percent, thus reducing the overall control efficiency, the following reduction potential percentages do not take capture efficiencies into account.

Emission Reduction for Three Regulatory Alternatives^a

Regulatory Alternative (Mg VOC per year)	Percent Reduction	
	Existing Landfills	New Landfills
25	92	90
150	79	69
250	71	57

^a A landfill that emits 150 Mg VOC/yr is estimated to be approximately 1 million Mg or 2.2 million cubic yards in size.

COST EFFECTIVENESS

EPA has conducted a cost-effectiveness analysis of a flare and extraction system at new and existing landfills. The analysis examined costs under three stringency levels – 25 Mg VOCs/yr (28 tons), 150 Mg VOCs/yr (165 tons) and 250 Mg VOCs/yr (276 tons). For the second level, 150 Mg VOC per year, EPA's analysis indicated that the cost of reducing VOCs would be \$1,020/Mg (\$930/ton) for new facilities and \$555/Mg (\$500/ton) for existing facilities. Energy recovery systems have the potential to offset the cost of control. However, the capital costs for these systems is higher than for flares and a site-specific study would be needed to determine the technical and economical feasibility of installing an energy recovery system for a given landfill.

The nationwide annualized cost for collecting and controlling air emissions from new municipal solid waste landfills is estimated at \$26 million. The nationwide cost of the proposed guidelines for existing facilities would be approximately \$240 million. The economic analysis indicates that the annual cost of waste disposal may increase by an average of less than \$1 per ton for the proposed New Source Performance Standard (NSPS) and the proposed Section 111(d) guidelines. Costs per household would increase by less than \$3 per year for a household served by a new landfill and by \$5 per year for one household served by an existing facility.

FEDERAL RULEMAKING AND/OR GUIDANCE DOCUMENTS

On May 30, 1991, EPA proposed in the Federal Register standards of performance for new municipal solid waste landfills and emission guidelines for existing municipal solid waste landfills (56 FR 24468). The standards and guidelines would require landfills emitting greater than 150 Mg per year (167 tons/yr) of VOCs to design and install gas collection systems and combust (with or without energy recovery) the captured gases. A final rule is expected to be promulgated in the fall of 1993.

STAPPA/ALAPCO Recommendation

► State and local agencies should consider the proposed NSPS as an adequate regulatory framework. However, agencies may find it necessary to lower the size cutoff below that suggested by EPA to reflect the major source definition for the area. Alternatively, California recommends regulating all landfills with greater than 500,000 tons of landfill in place.

❖ *For more information on these standards, contact Dennis Doll, U.S. Environmental Protection Agency, Emissions Standard Division, Research Triangle Park, NC 27711 (telephone: 919/541-5693).*

STATE AND LOCAL CONTROL EFFORTS

In Wisconsin, solid waste disposal facilities having a design capacity greater than 500,000 cubic yards and an acceptable municipal solid waste plan are required to install an approved system (Solid Waste Regulations, s. NR 506.08(6), Wisconsin Administrative Code). The system must efficiently collect and control air contaminants emitted by the facility to less than 25 percent of the lower explosive limit (LEL) at any time. In addition, the Air Management Regulation requires a source to control emissions of hazardous air pollutants to the atmosphere. A source must meet the Lowest Achievable Emission Rate or Best Available Control Technology (BACT), depending upon the pollutants emitted.

In Illinois, municipal waste landfills are regulated by Waste Disposal Rules and Regulations issued by the Illinois Pollution Control Board. The operator of a landfill is required to install a gas management system based on the methane concentration detected or if the malodors caused by the unit are detected beyond the property boundary. The processing of landfill gas is strongly encouraged. No gas may be discharged directly to the atmosphere unless it is treated or burned on-site prior to discharge in accordance with a permit issued by the agency. These rules are standard for on-site combustion of landfill gas using flares

or other devices. No emission standard currently exists for combustion of landfill gas in terms of control efficiency of the flare and other control devices.

Indiana Rule 329 IAC 2-14-20 regulates gaseous emissions from municipal landfills throughout the state. Methane gas must be monitored and the state must be notified when the 25-percent LEL is exceeded. Sources are required to limit the gas concentration to less than 25 percent of the LEL for such gases at any time.

In California, a suggested control measure (SCM) for landfill gas emissions requires a gas collection system for all landfills (both active and inactive) with more than 500,000 tons in place. Sites containing only inert waste are exempt. In 1990, the California Air Resources Board estimated that 43 sites would be affected by the SCM, with estimated collectible VOC emissions of 820 tons per year.

North Carolina requires that methane emissions not exceed 25 percent of the LEL. Several landfills in North Carolina and New York have installed cogeneration systems on their landfill vents to produce electrical power.

The South Coast Air Quality Management District (SCAQMD) has two rules intended to reduce gaseous emissions from the landfills in the South Coast Air Basin: Rule 1150.1, Control of Gaseous Emissions From Active Landfills; and Rule 1150.2, Control of Gaseous Emissions from Inactive Landfills.

The purpose of Rule 1150.1 is to reduce gaseous emissions from active landfills to prevent public nuisance and possible detriment to public health caused by exposure to such emissions. The rule requires the installation of a landfill gas collection system sufficient to draw landfill gas toward the gas control device without an overdraw that would adversely affect the system. The rule sets limits for surface emissions, calls for migration control and requires periodic monitoring. The rule also requires determination of efficiencies for the disposal system and periodic monitoring of these efficiencies. The compliance deadline for existing facilities was January 1, 1989.

Rule 1150.2 is intended to reduce gaseous emissions from inactive landfills. Based on the established criteria and available information, the SCAQMD will determine whether the gas generated from the landfill needs to be collected. If so, the owner must install a gas collection and control system under a compliance schedule set forth in the rule. The installation requirements, the surface emission limits, migration control and periodic monitoring requirements are identical to those in Rule 1150.1. Implementation of Rule 1150.2 is scheduled to begin in late 1993.

Rules 1150.1 and 1150.2 require the installation of collection and disposal/control systems. SCAQMD requires that the operator obtain an "Authority to Construct" prior to constructing and operating this equipment.

Regulation XIII requires, among other things, that any permit unit which emits more than 1 lb/day of a given criteria pollutant must be constructed with BACT. A number of gas disposal methods are available, including flaring, gas turbines, boilers, internal combustion engines and, in the case of very small gas flow and poor gas quality, carbon adsorption. Depending on the chosen disposal method, BACT for reactive organic gases (ROGs), such as VOCs, varies. Requiring BACT assures that ROG emissions from these facilities are minimized.

REFERENCES

1. Lake Michigan Air Directors Consortium. April 1993. *Evaluation Of Possible Control Measures for Control of Emission from Municipal Solid Waste Landfills*.
2. U.S. Environmental Protection Agency. May 30, 1991. *Standards of Performance for New Stationary Sources and Guidelines for Control of Existing Sources: Municipal Solid Waste Landfills*. Proposed Rule, Guideline and Notice of Public Hearing. 56 *Federal Register* 24468.
3. State of California Air Resources Board. September 1990. *Suggested Control Measure for Landfill Gas Emissions*. Resolution 90-57.

Table 1
Summary Table – Landfill Gases

Affected Facilities	All municipal solid waste landfills that received waste on or after November 8, 1987.
Number of Affected Facilities	Up to 6,000 active landfills and as many as 32,000 closed landfills.
National Emissions Estimates	283,000 tons per year of VOC (includes active landfills, as well as those closed after 11/8/87).
100 TPY Source Size	Based on California data, the average landfill emits less than 20 tons of VOCs per year.
Potential Emissions Reduction Per Facility	Based upon a 98-percent destruction efficiency, VOC emissions from existing sources emitting more than 150 Mg/yr would be reduced by 79 percent.
Cost Effectiveness	National annual costs: New Facilities - \$26,000,000 National annual costs: Existing Facilities - \$240,000,000 Cost effectiveness: New Facilities - \$930/ton VOC Existing facilities - \$500/ton VOC
Federal Rulemaking and/or Guidance Documents	Proposed rule published May 30, 1991. Final rule expected by fall 1993.
State and Local Control Efforts	WI -Requires gas collection system with thermal oxidation. IL - Requires oxidation; no control efficiency required. IN, NC -Require emissions to remain below 25% LEL. CA -Requires gas collection system for all landfills (both active and inactive) with more than 500,000 tons in place. SCAQMD -Rules 1150.1 and 1150.2 require gas collection and disposal/control systems for both active and inactive landfills.
STAPPA/ALAPCO Recommendation	Implement the proposed NSPS; lower the size cutoff to reflect the major source definition; consider regulating landfills with more than 500,000 tons in place.

Marina Gasoline Refueling

DESCRIPTION OF SOURCE CATEGORY

Marina gasoline refueling, or Stage II vapor recovery for boats, addresses VOC emissions from the refueling of boats at marinas. A marina may have anywhere from one to six refueling nozzles. However, not all boats are refueled at marinas; many are refueled at facilities other than marinas (e.g., when a trailered boat is refueled at a regular service station or is refueled with a gasoline can filled at a regular service station).

GEOGRAPHIC DISTRIBUTION OF SOURCES

Marinas that dispense gasoline are located in all coastal states, as well as in states that have pleasure boating on inland lakes or rivers. While there is little information available concerning the total number of facilities nationwide, state and local data can be extrapolated on a nationwide basis. Massachusetts, for example, reported 150 marinas (7 inland, 143 coastal), while San Diego reported 11 facilities. Massachusetts reported that 0.25 percent of the state's total gasoline consumption during the summer months is attributable to marinas. By applying this percentage to the nationwide annual gasoline consumption level for 1990 (116 billion gallons), one arrives at an esti-

mate of 290 million gallons for annual gasoline consumption through marinas. [Note: The application of the 0.25 percent summer-month consumption factor from Massachusetts to nationwide annual gasoline consumption may overestimate nationwide emissions, given that Massachusetts reported a summertime only daily consumption figure. In San Diego, highway gasoline use was about 12.8 billion gallons in 1989. The 1.5 million gallons dispensed at marinas is about 0.012 percent of annual gasoline sales.]

NATIONAL EMISSIONS ESTIMATES

Both the San Diego and the Massachusetts analyses estimated emissions from marinas using the AP-42 emission factor of 11 pounds per thousand gallons of gasoline dispensed. Based on this emission factor and the consumption estimate indicated above (290 million gallons), an estimated 1,600 tons per year of uncontrolled emissions of volatile organic compounds (VOCs) could be occurring from marina refueling facilities.

AVAILABLE CONTROL STRATEGIES

Stage II vapor recovery has been in place at many traditional service stations since the 1970s. Early Stage II vapor control devices use a boot over the nozzle spout to capture vapors displaced from vehicle tanks during refueling; the vapors are then routed to a storage tank through vapor piping.

Vapor balance systems require a tight fit at the nozzle/fill neck interface and use only displacement forces to capture and transfer emissions. Vacuum-assisted systems use a vacuum to capture vapors at the nozzle/fill neck interface. Such systems draw vapors into the nozzle boot in the absence of a tight fit.

POTENTIAL NATIONAL EMISSIONS REDUCTION

The emissions reduction achievable from Stage II vapor recovery are limited by certain technical problems. First, about 10 percent of the facilities (accounting for an estimated 15 percent of total throughput) are subject to a Coast Guard regulation that requires boat tanks to be equipped with submerged fill pipes. Stage II would not control any emissions from these boats since no vapors are emitted back through the fill pipe. About 20 percent of boats (accounting for an estimated 20 percent of total throughput) have fuel tanks on either side of the vessel with a liquid manifold running between them; each tank has its own vent line. San Diego estimates that only 38 percent of the emissions from these vessels would be collected with Stage II controls. These two technology limitations result in 27 percent of the consumption from marinas remaining uncontrolled, although estimates may vary depending upon boat population mix.

If one assumes that 50 percent of the refueling of boats occurs at marinas, and that 27 percent of this consumption could not be controlled by Stage II technology, the installation of Stage II vapor recovery devices at marinas would control approximately 51 percent of the total estimated consumption from marinas ($0.5 \times [1 - 0.27] = 0.37$). Assuming an efficiency for Stage II of 86 percent (the in-use efficiency with annual inspections; see chapter on Stage II vapor recovery for vehicle refueling), emissions reduction would be as follows:

$$(1,600 \text{ tons/yr})(0.37)(0.86) = 510 \text{ tons/yr}$$

California has an extensive certification process for Stage II systems. Most states are relying on this certification process and will accept Stage II systems only if they have been certified by California. However, California has not finished developing its certification program for vacuum-

STAPPA/ALAPCO Recommendation

► Stage I and II vapor recovery technology can be developed to address marinas almost as effectively as gasoline dispensing facilities. While the average cost-effectiveness estimates for marinas will be higher than for other gasoline dispensing facilities, because of lower throughput at marinas, the cost effectiveness of a facility dispensing 10,000 gal/month is estimated to be \$2500-\$3000/ton, which is comparable to the cost of Reasonably Available Control Technology at many VOC sources. Accordingly, state and local agencies should consider requiring Stage I and II vapor recovery at marinas that dispense more than 10,000 gal/month.

assisted systems with longer hoses, which will be needed on Stage II systems for boats.

System efficiency begins to decrease with time because of equipment defects (torn nozzle boots, kinked hoses, etc.). Studies have shown that in-use efficiency increases with the frequency of enforcement inspections. For example, if no inspections are conducted, the certification efficiency of 95 percent is reduced to 62 percent. If annual inspections are conducted, an in-use efficiency of 86 percent is expected. If semi-annual inspections are conducted, an in-use efficiency of 92 percent is expected. These in-use estimates were generated for typical vehicle refueling events and are assumed to apply to marinas.

However, applying typical service station system performance factors to marinas may be inappropriate. Vacuum-assisted systems are less prone to problems typically associated with kinked hoses at service stations. The vapor hose used on a 2-hose system is a 3/8-inch diameter soft-wall hose that does not kink like hard-wall hoses. A reverse coaxial hose may also be used, further limiting vapor hose damage. These systems are certified with a bootless nozzle, eliminating vapor losses from torn or missing bellows. Finally, hoses at marinas will not typically be run over by

motor vehicles and, further, attendants frequently dispense fuel at marinas. Consequently, the 86-percent control efficiency may underestimate actual emissions reduction performance.

COST EFFECTIVENESS

The cost effectiveness of controls at marinas is comparable to the cost effectiveness of Stage II vapor recovery at gasoline service stations with comparable throughputs; however, marinas tend to have lower throughputs than service stations.

FEDERAL RULEMAKING AND/OR GUIDANCE DOCUMENTS

The U.S. Environmental Protection Agency's (EPA's) technical guidance on Stage II vapor recovery for traditional vehicle refueling facilities does not address marinas.

STATE AND LOCAL CONTROL EFFORTS

Both San Diego and Massachusetts are contemplating regulations for marinas. San Diego indicated a 97-percent compliance rate based on a district marina refueling evaluation.

San Diego currently exempts tanks with less than 2,000 gallons per month throughput and less than 550 gallons capacity from Stage II service station controls, but it has not yet been determined if this will be extended to marinas.

The South Coast Air Quality Management District (SCAQMD) does not have a rule regarding Stage II vapor recovery for the refueling of boats at marinas, but is currently in the process of amending its rules to expand the list of equipment subject to Stage II vapor recovery and is considering boats at marinas. In addition, SCAQMD reported that previous technical problems with the boots of the fuel pipes of the marine boats are being addressed. For example, one recent development is the certification by California of bootless nozzles, which may be the appropriate fit for marine vessels.

REFERENCES

1. San Diego County Air Pollution Control District. *Tactic Revaluation - Marina Refueling*. pp. 394-400.
2. State of Massachusetts. April 16, 1993. *Strategy Evaluation Form - Stage II for Boats*.

Table 1
Summary Table - Marina Gasoline Refueling

Affected Facilities	Any marina dispensing gasoline.		
Number of Affected Facilities	Will vary from state to state depending on pleasure boating facilities. Gasoline consumption attributed to marinas was estimated by Massachusetts to be 0.25 percent of total gasoline consumption.		
National Emissions Estimates.	Nationwide annual VOC emissions estimated at 1,600 tons/yr		
National Emissions Range Per Facility	Gasoline Throughput (gallons per year) VOC emissions (tons/yr)	Small 40,840 0.2	Large 540,000 3.0
Potential National Emissions Reduction	VOC reductions of 86 percent can be achieved, assuming annual inspections. Considering exemptions and uncontrolled emissions, overall program efficiency of approximately 60 percent can be expected.		
Cost Effectiveness	Capital Annual Cost Effectiveness	Small \$11,500 \$1,600 \$15,400/ton	Large \$14,600 \$1,900 \$1,150/ton
Federal Rulemaking and/or Guidance Documents	No federal activities are occurring at this time. See "Stage II Vapor Recovery" chapter for applicable guidance.		
State and Local Control Efforts	Several areas are considering extending Stage II rules for service stations to cover marinas.		
STAPPA/ALAPCO Recommendation	Require Stage I and II vapor recovery at marinas that dispense more than 10,000 gal/month.		

Marine Vessel Loading

DESCRIPTION OF SOURCE CATEGORY

Marine vessel loading refers to the loading of tank ships and barges with volatile liquids; this category does not apply to ship fueling and lightering. The following 13 commodity categories contain volatile organic liquids that would be regulated under a federal rule: gasoline, crude oil, jet fuel, alcohols, distillate fuel, crude products, naphthas/solvents, toluene, basic chemicals, miscellaneous chemicals, petroleum and coal products, gum and wood chemicals and kerosene.

Evaporative emissions from marine vessel loading occur primarily as a result of loading losses. Ballasting losses also contribute a small portion of emissions, however, pursuant to 33 CFR Parts 157.132 and 157.168, ballasting emissions must be controlled in designated ozone nonattainment areas.

Loading losses occur when organic vapors in an empty marine vessel are displaced by the incoming liquid. Loading losses vary according to the type of vessel and vessel-arrival conditions. Ballasting losses are generated when sea water is pumped into an empty, vapor-laden cargo tank to provide stability for the vessel. Vapors displaced by the water escape to the atmosphere through tank vents.

GEOGRAPHIC DISTRIBUTION OF SOURCES

According to EPA, there are approximately 1,650 marine terminals in the United States where at least one of the 13 volatile liquids mentioned above are loaded. About half of the terminals load gasoline and/or crude oil. The remainder load at least one of the other categories of liquids. Marine terminals are found along the Atlantic, Gulf and Pacific coasts. Inland terminals can be found on major rivers and on the Great Lakes.

NATIONAL EMISSIONS ESTIMATES

Several factors influence emissions levels from marine vessel loading operations. These include the type of vessel loaded (i.e., tanker versus barge); the product previously carried in the cargo vessel; the volatility (i.e., Reid Vapor Pressure) of the product being loaded; the product temperature; and the temperature differential between the loaded product and the storage vessel. A technical support document prepared by the U.S. Environmental Protection Agency (EPA) on volatile organic compound (VOC) and hazardous air pollutant emissions from marine vessel loading operations provides VOC emission factors for the various commodities loaded into marine vessels. For example,

the VOC emission factor for loading crude oil into a tank ship is 0.61 lb/1,000 gallons loaded, while the emission factor for loading crude oil into a barge is 1.00 lb/1,000 gallons loaded. The emission factors for barges are typically higher than for tank ships due to differences in the configuration of their storage tanks.

According to EPA, national VOC emissions from marine cargo loading total about 85,000 tons/yr. Ninety-five percent of the emissions result from crude oil and gasoline loading. The remaining 5 percent come from the other 11 commodity categories.

AVAILABLE CONTROL STRATEGIES

Vapor balancing, refrigeration, carbon adsorption, incineration or a combination of these methods can be used to reduce VOC vapor emissions from marine vessel loading. The emissions control equipment can be located either on the vessel itself or onshore at the terminal. The control methods require a shipboard vapor collection system, a ship-to-shore connection, a shoreside vapor transfer system and a final control device.

Vapor balancing can be used to control VOC emissions during the loading of marine vessels, when uncontrolled vapors in an empty cargo tank are displaced to the atmosphere through the tank vent. Vapor balancing utilizes a vapor balance line that is connected to the tank vent. The vapor balance line directs the collected vapors to one of the following: 1) another empty cargo tank, which would store the vapor under a slight pressure; 2) an on-board control device (e.g., a refrigeration system); or 3) an off-site control device near the terminal. Applicable final control devices include thermal incinerators, carbon adsorbers, or refrigeration units.

Two examples of thermal oxidation are flares and incinerators. Thermal oxidation processes do not recover any of the loaded product. A flare burns VOCs by igniting the vapor stream as it passes through one or more burners. Flares require very little attention and will burn on their own as long as the incoming vapor stream contains sufficient flammable material. Incinerators operate in a similar fashion by burning VOC vapors in a confined chamber. The vapors enter the incinerator chamber, combust and then exit through an exhaust stack. Thermal oxidation controls are desirable at facilities where multiple products are loaded.

Vapor recovery processes involve collecting and condensing vapors so that emissions are kept to a minimum and a product is recovered. Recovery processes include carbon adsorbers, vapor compressors, refrigerated condensers and lean oil absorbers. Such processes are generally more complex to design and operate. Recovery is often

feasible and desirable in instances where only one product is being loaded.

Carbon adsorbers use activated carbon to adsorb hydrocarbons. Carbon adsorbers should not be used at terminals where hydrogen sulfide (H₂S) is present in the vapor stream (i.e., vapors from crude oil). H₂S poisons the carbon bed and renders it useless. Refrigeration systems remove hydrocarbons by cooling and condensing the vapors through a series of low-temperature heat exchangers. Lean oil absorbers use condensation and cooling under pressure to transfer or absorb hydrocarbons from a vapor into a lean oil.

Flame arresters and antidetonation devices may be required on ducts and pipes carrying hydrocarbons to provide adequate safety. Also, secondary emissions of nitrogen oxides, sulfur dioxide, carbon monoxide and carbon dioxide occur when hydrocarbon vapors are incinerated. However, carbon adsorption produces waste carbon that must be recycled or discarded in a suitable landfill.

POTENTIAL NATIONAL EMISSIONS REDUCTION

Techniques to reduce VOC vapor emissions from marine vessel loading can achieve the following levels of efficiency:

- Carbon adsorbers can achieve up to 99-percent efficiency in the removal of hydrocarbons, except for light-end substances, such as ethane and propane;
- Refrigeration systems can remove up to 99 percent of VOCs in the vapor stream if operating at a very low temperature (-150°F);
- Lean oil absorbers are 80-percent to 90-percent effective at removing hydrocarbons by increasing pressure and approximately 95-percent effective by lowering temperatures;
- Flares are typically 98-percent efficient, as long as the combustion zone stays properly lighted; and
- A regenerative incinerator, which has heat exchange media upstream and downstream of the emission chamber, can be 99-percent or more effective in controlling emissions and approximately 70-percent energy effective.

COST EFFECTIVENESS

The cost of controlling VOC emissions from marine vessel loading operations includes the cost of retrofitting both the marine terminals and the vessels that load at these terminals. To simplify cost-estimating procedures, EPA's technical support document for marine vessel loading

developed four model vessels and eight model terminals. Table 1 compares the costs of applying carbon adsorption or thermal incineration at the eight model terminals. EPA's technical support document provides detailed information describing the model terminals and vessels and how their associated costs were developed. In general, cost effectiveness ranges from \$560/megagrams (Mg) to \$7,500/Mg.

FEDERAL RULEMAKING AND/OR GUIDANCE DOCUMENTS

In May 1992, EPA issued a technical support document for proposed standards for marine vessel loading operations.

Currently, marine vessels loading volatile liquids containing more than 70 weight-percent benzene are regulated by 40 CFR 61, Subpart BB, "National Emission Standard for Benzene Emissions from Benzene Transfer Operations"; this rule became effective on July 23, 1991. Facilities affected by this standard must equip each loading rack with a vapor collection system and install a control device to reduce benzene emissions routed to the atmosphere through the control device by 98 weight-percent. Facilities with annual benzene loading of less than 1.3 million liters of 70 weight-percent benzene are exempt from this regulation.

EPA is currently developing standards for tank vessel loading operations. The regulation, which is scheduled for promulgation in August 1994, will control both VOCs and hazardous air pollutants from tank vessel loading operations.

STATE AND LOCAL CONTROL EFFORTS

Several states, including Louisiana, Pennsylvania, New Jersey, New York and Alaska have enacted regulations to control VOC emissions from marine vessel loading operations. In addition, California local air districts, including the Bay Area Air Quality Management District (BAAQMD), the South Coast Air Quality Management District (SCAQMD), and the Santa Barbara County Air Pollution Control District have enacted similar regulations. Table 2 contains a comparison of various state and local regulations.

REFERENCES

1. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. May 1992. *VOC/HAP Emission from Marine Vessel Loading Operations—Technical Support Document for Proposed Standards (Draft EIS)*. EPA-450/3-92-001a.

STAPPA/ALAPCO Recommendation

► Marine vessel loading operations can achieve 95-percent control efficiency. Several agencies currently require equal or better performance. BAAQMD, for example, has adopted a mass limit of 5.7 micrograms/liter in addition to the 95-percent control requirement.

In that virtually all terminals have the potential to be major VOC sources, state and local agencies should assume all terminals are controllable and develop exceptions only where local circumstances warrant them. For example, SCAQMD exempts terminals having loading events of less than 1,000 barrels.

2. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. September 1985. *Compilation of Air Pollutant Emission Factors. Volume I: Stationary Point and Area Sources—Fourth Edition*. Chapter 4.4.
3. California Air Resources Board. January 8, 1991. *Determination of Reasonably Available Control Technology and Best Available Retrofit Control Technology for Marine Vessel Loading Operations*.
4. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. February 1993. *Gasoline Distribution Industry (Stage I) - Background Information for Proposed Standards*. Draft EIS.
5. U.S. Department of Transportation, U.S. Coast Guard. *Marine Vapor Control*. July 23, 1990. 33 CFR Part 154 et al, 46 CFR Part 30.
6. National Research Council, Committee on Control and Recovery of Hydrocarbon Vapors from Ships and Barges, Marine Board, Commission on Engineering and Technical Systems. 1987. *Controlling Hydrocarbon Emissions from Tank Vessel Loading*. Washington: National Academy Press.

Table 1**Summary of Costs and Cost Effectiveness of EPA's Model Terminals^a**

Model Terminal Control	Capital Cost (\$)	Annual Cost (\$)	Cost Effectiveness (\$/Mg)
5A - Inc ^b	8,650,000	1,670,000	1,600
5A - CA ^c	8,330,000	1,560,000	1,600
5B - Inc ^b	4,680,000	941,000	1,900
5B - CA ^c	4,310,000	815,000	1,700
5C - Inc ^b	2,660,000	564,000	2,200
5C - CA ^c	2,290,000	466,000	1,900
6A - Inc ^b	3,870,000	703,000	880
6A - CA ^c	d	d	d
6B - Inc ^b	4,680,000	941,000	6,300
6B - CA ^c	d	d	d
6C - Inc ^b	2,660,000	564,000	7,500
6C - CA ^c	d	d	d
7A - Inc ^b	5,980,000	1,260,000	1,200
7A - CA ^c	5,000,000	1,680,000	1,600
7B - Inc ^b	14,300,000	2,830,000	1,100
7B - CA ^c	12,800,000	1,460,000	560

^aSee Reference 1 for description of models 5A through 7B.^bInc: controlled by an incinerator.^cCA: controlled by a carbon absorber.^dCarbon absorbers are not a feasible control device to use at model terminals 6A, 6B, 6C. Since these terminals load only crude oil that has hydrogen sulfide – which poisons the carbon bed – in the vapor stream.

MARINE VESSEL LOADING

Table 2

Comparison of State and Local Regulations Governing Marine Loadings^a

	San Francisco Bay Area	South Coast Air Basin	Louisiana
Regulation name	Regulation 8, Rule 44	Rule 1142	Rule 2108
Governing body	BAAQMD	SCAQMD	Louisiana Dept. of Environmental Quality
Gasoline emissions	5.7 mg/l or 95% reduction	2 lbs/1000 bbl or 95% reduction	70 mg/l for barges 30 mg/l for ships
Crude oil emissions	5.7 mg/l or 95% reduction	2 lbs/1000 bbl or 95% reduction	30 mg/l for barges 12 mg/l for ships
Other VOC emissions ^b	5.7 mg/l or 95% reduction	2 lbs bbl or 95% reduction	30 mg/l for barges 12 mg/l for ships
Affected facilities	All terminals	All terminals	All with uncontrolled emissions >100 ton/yr
Compliance dates	July 1, 1991, for facilities except small terminals (<1 X 106 bbls/yr) and limited trade vessels (<3 loadings/yr), both of which must comply by July 1, 1992	Effective January 1, 1994	December 31, 1991, for gasoline and other VOCs May 1, 1992, for crude oil
Special notes	Small terminal is one loading less than 1 million bbl/yr. Tank vessel must be leak-free and gas-tight	Rule 1142 controls VOC emissions during loading, lightering, ballasting and housekeeping events	90% reduction in emissions is allowable instead of mg/l limits Allows the use of open flares if they are designed and operated per EPA guidelines

Table 2 – Continued

	New Jersey	Alaska	Pennsylvania
Regulation name	NJAC-7-27-16.3	18 AAC 50, 105, 500, and 900 (proposed regulation)	29 PA, CODE CHS, 121, 129 and 139
Governing body	New Jersey Department of Environmental Protection and Energy	Alaska Department of Environmental Conservation	Pennsylvania Environmental Quality Board
Gasoline emissions	95% reduction	95% reduction or 2 lb/1,000 bbl	90% reduction
Crude oil emissions	Exempt	95% reduction of 2 lb/1,000 bbl	Exempt
Other VOC emissions ^b	Exempt	95% reduction or 2 lb/1,000 bbl	Exempt
Affected facilities	All loading more than 6 million gal/yr of gasoline	All terminals with throughputs greater than 5 million bbl/yr or with uncontrolled VOC emissions greater than or equal to 250 tons	All terminals
Compliance dates	June 21, 1991	June 1992	September 1996
Special notes	Any facility that loads 60,000 gal/day between May 1 and September 15 is affected	Facilities emitting 250 tons (or greater) of VOCs per year are considered "major" facilities Alaska's proposed regulation was patterned after the rules developed by the BAAQMD	The proposed amendments require control of ballasting emissions

^aSOURCE: Chemical Engineering, May 1990.^bIn San Francisco, VOC's include gasoline blending stocks and aviation fuel; in Louisiana, they include any VOC that boosts a terminal to 100 ton/yr and has a true vapor pressure greater than 1.5 pounds per square inch actual (e.g., JP-4 (jet fuel), aviation gas, gasoline blending stocks), at the loading temperature; SCAQMD has established an alternate VOC emissions limit of 2.0 lb per 1,000 bbl loaded.

Table 3

Summary Table – Marine Vessel Loading

Affected Facilities	Tank ships and barges loaded with gasoline, crude oil, jet fuel, naphtha/solvents, alcohols, toluene, distillate fuel, basic chemicals, miscellaneous chemicals, petroleum and coal products, crude products, gum and wood chemicals and kerosene.			
Number of Affected Facilities	1,648 marine terminals nationwide, assuming no exemptions (1988 estimate).			
National Emissions Estimates	Uncontrolled nationwide VOC emissions from marine loading totaled 85,000 tons/yr in 1988.			
VOC Emissions Range Per Facility	Size ^a	Small	Medium	Large
	Product Throughput, bbl/Yr	100,000	1,000,000	5,000,000
	VOC Emissions from Cargo Loading			
	Tank ships	1.3	12.8	64
	Barges	2.1	21.0	105
100 TPY Source Size	Tank ships and barges that have a high throughput of gasoline or crude oil would meet the 100 ton/year emission source.			
	Annual Throughput Required to be Classified as 100 TPY			
	Crude Oil	Gasoline		
	Tankship	7,800,000 bbl	2,600,000 bbl	
	Barge	4,800,000 bbl	1,400,000 bbl	
Cost Effectiveness	See Table 1.			
Potential Reduction Emissions Per Facility	VOC reduction per controlled facility ranges from 80 percent to 98 percent, depending on the type of control. Vapor balancing, vapor collection and vapor combustion are available control options.			
Federal Rulemaking and/or Guidance Documents	EPA has prepared a technical support document including proposed standards applicable to marine vessel loading operations. Currently, marine vessels loading volatile liquids containing more than 70 percent benzene by weight are regulated under 40 CFR 61, Subpart BB, "National Emission Standard for Benzene Emissions from Benzene Transfer Operations"; this rule became effective on July 23, 1991. EPA is currently developing standards for tank vessel loading operations. The regulation, which will control both VOCs and HAPs from tank vessel loading operations, is scheduled for promulgation in August 1994.			
State and Local Efforts	BAAQMD, SCAQMD, Louisiana, New Jersey, Alaska and Pennsylvania have marine vessel loading rules.			
STAPPA/ALAPCO Recommendation	Require at least 95-percent control from marine vessel loading operations.			

^aAssumes that marine vessel is loaded with crude oil.

Offset Lithographic Printing

DESCRIPTION OF SOURCE CATEGORY

Offset lithographic printing is used in a variety of paper printing applications (e.g., books, magazines, catalogs, business forms, newspapers, calendars and stamps). Approximately 70 percent of all newspapers printed in the United States use offset lithography.

Other printing processes, such as rotogravure and letterpress, use raised or recessed surfaces to print an image. By contrast, lithography is a planographic method of printing in which the image and nonimage areas occupy the same plane on the surface of a thin metal lithographic plate. The image and nonimage areas are distinguished chemically. The lithographic plate is prepared in such a way that the image area is rendered oil receptive and water repellant. A water-based "fountain solution," which is applied to the lithographic plate, renders the nonimage area receptive to water and nonreceptive to ink. Although the fountain solution is water-based, it contains isopropyl alcohol (IPA), which reduces the surface tension of the water.

During printing, ink is transferred from an ink reservoir onto rollers. The rollers then transfer the ink onto the lithographic plate. The lithographic plate transfers the ink

image onto a rubber-covered blanket cylinder, which prints the ink image onto the substrate.

After printing, the substrate is dried. The drying method depends on whether a "heatset" or "nonheatset" ink is used. Heatset inks pass through a heated dryer where most of the ink oils evaporate. In the nonheatset ink process, the inks dry by absorption into the substrate, by oxidation or by other nonheat processes.

Throughout this process, there are three primary sources of VOC emissions: printing inks, from which most of the ink oils evaporate in the dryers; the fountain solution, which contains IPA; and cleaning solutions, which are primarily organic solvents.

It is important to note that not all of the volatile organic compounds (VOCs) in offset inks evaporate to the atmosphere; some are retained in the substrate. EPA's draft Control Techniques Guideline (CTG) assumes that 95 percent of the VOCs measured by Method RM-24 are retained in the substrate for nonheatset inks; for heatset inks, it is assumed that 20 percent of the VOCs are retained in the substrate.

GEOGRAPHIC DISTRIBUTION OF SOURCES

The printing industry (sometimes referred to as the graphic arts industry) is included under the Standard Industrial Classification (SIC) Code 27, "Printing, Publishing, and Allied Industries." SIC 27 includes all commercial, publishing, and newspaper printing. Based on the number of employees, offset lithography comprises approximately 64 percent of the SIC 27 category.

Printing ranks as one of the top 10 manufacturing industries in the United States. Fifty-seven percent of the printing industry is located in the North Central (Illinois, Indiana, Michigan, Ohio and Wisconsin), North Atlantic (New Jersey, New York and Pennsylvania), and Pacific (Alaska, California, Hawaii, Oregon and Washington) regions. There are more than 34,000 lithographic printing facilities located in ozone nonattainment areas. Approximately 7,500 of these facilities emit more than 10 tons per year.

NATIONAL EMISSIONS ESTIMATES

VOC emissions occur from printing inks, the fountain solution and cleaning products. It is estimated that almost 820,000 tons of VOCs are emitted annually from lithographic printing facilities in ozone nonattainment areas. Approximately 77 percent of all VOC emissions resulting from lithographic printing occur from the fountain solution, 15.4 percent from the cleaning solutions and 7.6 percent from the inks.

AVAILABLE CONTROL STRATEGIES

There are three sources of VOC emissions from offset lithographic printing: emissions from dryers used to dry heatset inks, fugitive emissions from the fountain solution and fugitive emissions from the cleaning solutions. Emissions from these sources can be controlled by using add-on controls, modifying the production process and/or reformulating/substituting some of the materials used.

Add-on Controls: In offset lithographic printing, add-on controls are used to control VOC emissions in the exhaust from the hot air dryers used to cure heatset inks. Typical add-on controls used in heatset web offset lithographic printing include thermal incinerators, catalytic incinerators and condenser filter systems. Thermal and catalytic incinerators destroy the VOCs in the emissions stream, while the condenser filter systems recover solvents to be burned in dryers or boilers as supplemental fuel.

Process Modifications: Process modifications are alterations in operating methods or equipment, resulting in improved VOC control. One process modification is to

cool the fountain solution containing IPA, thereby reducing VOC emissions. Also, some printers have reduced or eliminated the amount of IPA in the fountain solution.

Reformulation: Material reformulation includes using nonalcohol additives in the fountain solution, including less volatile compounds such as ethylene glycol, propylene glycol, or glycol ethers. Cleaning solutions with a lower VOC content or low vapor pressure can be used; however, some of these low-VOC cleaners contain hazardous air pollutants (HAPs).

POTENTIAL NATIONAL EMISSIONS REDUCTION

If Reasonably Available Control Technology (RACT) were applied to all offset lithographic printing facilities located in ozone nonattainment areas, it is estimated that over 468,000 tons of VOCs could be eliminated, reducing national emissions by almost 60 percent. If RACT were applied only to facilities emitting more than 10 tons of VOCs per year in ozone nonattainment areas, it is estimated that approximately 415,000 tons of VOCs could be eliminated.

Catalytic and thermal incineration can achieve up to 98-percent VOC removal efficiency. Condenser filter systems typically achieve approximately 90-percent removal efficiency; however, if an activated carbon canister is placed on the outlet of the filter exhaust, 95-percent VOC removal is possible.

Cooling the fountain solution trays to about 55°F to 60°F has been shown to reduce alcohol consumption by as much as 44 percent.

Typical cleaning solutions usually consist of 100 percent VOCs. However, some cleaning compounds are available with VOC contents ranging from 0 to 30 percent by weight. According to EPA, industry officials have questioned the efficacy of low-VOC cleaners. Recently, some printers have switched to a low-vapor-pressure (slow-evaporating) organic solvent cleaner. Although these slow-evaporating cleaners are 100 percent VOCs, early reports indicate the potential for significant reductions in emissions because less solvent is used and consumed. The industry may request that the EPA recommend the slow-evaporating organic cleaners as an emissions reduction option.

COST EFFECTIVENESS

The U.S. Environmental Protection Agency's (EPA's) draft CTG for offset lithographic printing analyzes the costs of controls on a model plant basis. The four types of model plants use the following substrate feeding methods: heatset web, nonheatset web (non-newspaper), nonheatset sheet-

fed and newspaper nonheatset web. The model plants range in size from small to large and may operate one to ten presses.

Add-on Controls: The results of EPA's cost analysis for add-on controls are shown below. The CTG analysis assumed that 60 percent of the heatset dryers were already controlled. In general, add-on controls have a cost effectiveness ranging from \$1,300 to \$3,100 per ton of VOC removed.

Cost Effectiveness for Add-On Controls^a

Control Device	Annual Cost (\$/yr)	VOC Emission Reduction (tons/yr)	Cost Effectiveness (\$/ton VOC removed)
Incinerator	\$76,000-\$351,000	24-194	\$1,700-\$3,100
Condenser Filter (without carbon)	\$50,000-\$230,000	22-178	\$1,300-\$2,300
Condenser Filter (with carbon)	\$69,000-\$290,000	23-188	\$1,500-\$3,000

^a See Reference 1.

Process Modifications: Decreasing alcohol consumption by employing process modifications, such as cooling the fountain solution tank, can provide a net savings for many facilities, depending on the reduction of alcohol used.

Material Reformulation or Substitution: Using nonalcohol additives (alcohol substitutes) to reduce VOC emissions from the fountain solution can result in a credit (or savings) of \$920 per ton of alcohol not used. Although the additives or substitutes are more expensive than alcohol, smaller quantities are needed. Despite the potential savings, industry officials are concerned that switching to alcohol substitutes may at first decrease production due to the retraining that may be necessary. Switching to low-VOC cleaning solutions (30 percent VOC content) incurs an incremental annual cost ranging from \$1,100 to \$24,100 with an emissions reduction of 1.8 and 38.4 tons per year, respectively. The resulting cost effectiveness ranges from \$606 to \$628 per ton of VOC removed.

FEDERAL RULEMAKING AND/OR GUIDANCE DOCUMENTS

EPA circulated a draft review copy of a CTG for the offset lithographic printing industry in September 1991. The draft CTG is under review by the Office of Management and Budget (OMB) and is expected to be made final in the summer of 1994. The recommended levels of control for RACT are as follows.

Inks:

Heatset inks: 90-percent control (exhaust from dryers)

Fountain

Solution:

Heatset web: No greater than 1.6 percent alcohol by volume or no greater than 3.0 percent alcohol by volume if the solution is refrigerated to less than 60°F. Higher levels of control are possible by using alcohol substitutes or less alcohol in the fountain solution.

Sheet-fed: No greater than 5.0 percent alcohol by volume or no greater than 8.0 percent alcohol by volume if the solution is refrigerated. Higher levels are possible by using alcohol substitutes or less alcohol.

Nonheatset web: Nonalcohol additives or alcohol substitutes are used so that the final solution is less than 3.0 percent additive by volume.

Cleaning

Solution:

No more than 30 percent VOC content.

EPA also is developing a National Emission Standard for Hazardous Air Pollutants (NESHAP) for the printing/publishing industry. The agency is currently gathering background information on the various printing applications used in the printing/publishing industry, including offset lithography. EPA plans to promulgate this regulation by November 1995.

STATE AND LOCAL CONTROL EFFORTS

Illinois regulates heatset web offset lithographic printing under its air pollution regulation, Title 35, Section 218.405.

Wisconsin establishes organic compound control requirements for lithographic printing lines under Wisconsin's Administrative Code, Section 424.03, which requires that organic emissions be controlled by at least 85 percent.

Michigan's Administrative Rule 624, which went into effect January 1, 1983, regulates existing graphic arts operations. However, Rule 624 exempts offset lithographic printing operations.

Maryland regulates sheet-fed and web lithographic printing under COMAR 26.11.19.11.D-E. Under the requirements for sheet-fed printing, any person operating a press with a cylinder with a width greater than 18 inches

STAPPA/ALAPCO Recommendation

► Agencies should consider requiring the elimination of IPA from offset lithographic printing operations, since this is the largest source of emissions from this category. Except for sheet-fed operations and a few high-quality print jobs, elimination of all IPA is technically feasible. EPA's draft model rule allows 1.6 percent IPA for heat-set offset lithographic presses (3 percent IPA if refrigerated below 60°F). These limits should be considered only as interim limits as sources phase in IPA-free systems.

Cleaning solutions with no VOCs are available. Low-solvent cleaning solutions range from 0 to 30 percent solvent. Use of low-solvent cleaning solutions should be considered as interim limits as solvent-free or low-vapor-pressure cleaning solutions are phased in.

Only 8 percent of the emissions from offset lithography are from the ink dryers. These can be controlled by 95 percent with add-on controls; overall collection efficiency should be at least 70 percent. Alternatively, in lieu of add-on controls, inks with a VOC content of less than 300 grams per liter can be considered RACT.

must refrigerate the fountain solution to at least 55°F. If IPA is used, the operator must monitor the fountain temperature and limit the IPA content to less than 8.5 percent by weight. Under the requirements for lithographic web printing, any press that has VOC emissions greater than 20 pounds per day must refrigerate the fountain solution to less than 55°F, monitor the fountain temperature, install and operate a thermal or catalytic afterburner to control VOCs in the dryer exhaust and discontinue the use of isopropanol in the fountain solution.

Kansas regulates lithographic printing operations under Rule 28-19-76. Under this regulation, the fountain solution must not contain more than 10 percent alcohol by weight and must be maintained at 55°F or less if alcohol is used. If the press emits more than 10 tons per year of VOCs and uses a dryer, 100 percent of the dryer exhaust must be ducted to a control device that achieves at least 85 percent (by weight) VOC control efficiency.

Missouri has regulated lithographic printing operations under Title 10 CSR-2:340 since December 9, 1991. In general, Missouri has the same requirements for lithographic printers as Kansas.

The South Coast Air Quality Management District (SCAQMD) regulates offset lithographic printers emitting more than 8 pounds of VOCs per day. If control devices are used, they must reduce VOCs by 95 percent by weight. Collection equipment must operate at 70-percent efficiency. Facilities may opt to use formulation standards that require the use of inks with 300 grams or less of VOC per liter (less water and exempt solvents).

The Bay Area Air Quality Management District (BAAQMD) requires that collection and control equipment be at least 75-percent effective or that the control system be at least 90-percent effective. The facilities may opt for formulation standards that require inks to have less than 2.5 pounds of VOCs per gallon and fountain solutions to have a VOC content of 15 percent or less by volume.

Under the New York City regulations for offset printing, printers must use either an air cleaning device with at least 90-percent efficiency or a fountain solution containing no more than 10 percent VOCs by weight.

REFERENCES

1. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. December 14, 1992. *Control Techniques Guideline for Offset Lithographic Printing*. Draft.
2. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. June 16, 1992. "National Impacts of RACT for Offset Lithographic Printing." Letter from Heather Brown (Radian Corporation) to Karen Catlett (U.S. Environmental Protection Agency).
3. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. May 5, 1993. *Background Report - AP-42 Section 4.9 Graphic Arts*.

OFFSET LITHOGRAPHIC PRINTING

Table 1.....

Summary Table – Offset Lithographic Printing

Affected Facilities	According to EPA's Offset Lithographic Printing CTG Model Rule, affected facilities are those involved in the following lithographic printing processes: heatset web, nonheatset web (non-newspaper), nonheatset sheet-fed and newspaper (nonheatset web).
Number of Affected Facilities	More than 34,000 facilities will be affected by this model RACT rule. Currently, there is no size restriction or cut-off for small printers.
National Emissions Estimates	More than 820,000 tons of VOCs are emitted annually from lithographic printing facilities located in ozone nonattainment areas. Approximately 72 percent of the emissions are emitted from the fountain solutions containing IPA, 15.4 percent from the cleaning solution and 7.6 percent from the inks.
VOC Emissions Range Per Facility	<p><u>VOC Emission From Inks</u></p> <p>Heatset: 25 to 200 tpy</p> <p>Nonheatset sheet-fed: 1 to 14 tpy</p> <p>Nonheatset web (newspaper): 10 to 2,155 tpy</p> <p>Nonheatset and heatset web facilities: 77 to 618 tpy</p> <p><u>VOC Emission From Fountain Solutions</u></p> <p>Alcohol-based solution: 1 to 600 tpy</p> <p>Nonalcohol-based solution: 0.1 to 15 tpy</p> <p>(newspaper)</p> <p><u>VOC Emission From Cleaning Solutions</u> 1 to 55 tpy</p>
100 TPY Source Size	According to the draft CTG, a small uncontrolled heatset web and a small uncontrolled nonheatset web (non-newspaper) facility with "baseline" emission rates could qualify as 100 ton per year sources. "Small" is distinguished as having a total of 10 to 19 employees.
Potential Emissions Reduction Per Facility	<p>VOC reduction from heatset inks: 24 to 194 tpy per facility (using add-on control devices)</p> <p>VOC reduction from fountain solution: 0.1 to 556 tpy per facility</p> <p>VOC reduction from using lower VOC cleaner: 0.7 to 38.4 tpy per facility</p>
Cost Effectiveness	<p>Using add-on controls: \$1,300 to \$3,100 per ton VOC removed</p> <p>Cooling the fountain solution or using alcohol substitutes: Net savings</p> <p>Using low-VOC cleaners: \$600 per ton VOC removed</p>
Federal Rulemaking and/or Guidance Documents	<p>EPA circulated a draft review copy of a CTG for the offset lithographic printing industry in September 1991. The draft CTG is under review by OMB and is expected to be made final in the summer of 1994. The recommended levels of control for RACT are as follows:</p> <p>Heatset web: No greater than 1.6 percent alcohol by volume or no greater than 3.0 percent alcohol by volume if the solution is refrigerated to less than 60°F. Higher levels of control are possible by using alcohol substitutes or less alcohol in the fountain solution.</p> <p>Sheet-fed: No greater than 5.0 percent alcohol by volume or no greater than 8.0 percent alcohol by volume if the solution is refrigerated. Higher levels can be achieved by using alcohol substitutes or less alcohol.</p> <p>Nonheatset web: Nonalcohol additives or alcohol substitutes are used so that the final solution is less than 3.0 percent additive by volume.</p> <p>EPA is also developing a NESHAP for the printing/publishing industry and is currently gathering background information on the various printing applications used in the printing/publishing industry, including offset lithography. EPA plans to promulgate this regulation by November 1995.</p>
State and Local Control Efforts	Illinois, Wisconsin, Maryland and Kansas have set regulations to control VOCs from offset lithographic printing operations. In addition, three local authorities, the South Coast Air Quality Management District, the Bay Area Air Quality Management District and the New York Metropolitan Area regulate lithographic printing. Most state and local agencies regulate the fountain solution requiring a minimum temperature threshold (55°F to 60°F) and a maximum IPA content. Also, some agencies require a maximum VOC content for the printing inks and a minimum control efficiency for add-on control devices.
STAPPA/ALAPCO Recommendation	Eliminate isopropyl alcohol; control emissions from ink dryers by 95 percent with additional controls; alternatively, require inks with a VOC content less than 300 g/l.

Pesticide Application

DESCRIPTION OF SOURCE CATEGORY

In most state and federal laws, pesticides are termed economic poisons and are classified either according to the type of pest they are used to control or by their mode of action. Although there are more than 25 pesticide classes, the most widely used agricultural pesticides are herbicides and insecticides. These two classes make up approximately 80 percent of the total agricultural use of pesticides. The active ingredient in these pesticides is packaged, or formulated, for use in many different ways, depending upon the specific active ingredient and the intended use of the product. Nonaqueous liquid formulations have the greatest potential to emit volatile organic compounds (VOCs) because of the volatile organic solvents used to prepare the commercial product.

This chapter addresses VOC emissions related to the application of pesticides in agricultural and industrial settings. Use of pesticides in the home is addressed in the commercial/consumer products chapter.

GEOGRAPHIC DISTRIBUTION OF SOURCES

Pesticides are used throughout the country. Table 1, from the U.S. Environmental Protection Agency's (EPA's) Alter-

native Control Technology (ACT) document, presents pesticide use data for the top five pesticide-using states.

NATIONAL EMISSIONS ESTIMATES

Table 2 presents data on VOC emissions resulting from the application of insecticides and herbicides. A state-by-state breakdown of this information can be found in EPA's ACT document. The estimate of insecticide use in ozone nonattainment areas was made indirectly, based on a proration of herbicide data in nonattainment areas. The use of total solvent quantities to estimate VOC emissions assumes complete volatilization of the organic solvent. As shown in Table 2, the VOC emissions resulting from applications of agricultural herbicides and insecticides containing non-aqueous solvents total about 46,400 tons per year on a nationwide basis and about 4,800 tons per year in nonattainment areas. National emissions estimates have a considerable degree of uncertainty due to the lack of data and the estimation techniques used.

An active ingredient (AI) in a synthesized pesticide is a VOC if it is an organic compound and has the potential to be released into the atmosphere upon application.

AVAILABLE CONTROL STRATEGIES

Techniques for reducing VOC emissions from the application of agricultural pesticides include:

- Reformulating organic-solvent-containing pesticide formulations (e.g., emulsifiable concentrates);
- Reducing fumigant usage;
- Using alternative application methods;
- Applying microencapsulation techniques;
- Using integrated pest management (IPM);
- Using alternative active ingredients; and
- Reducing the use of crop oils.

These techniques may be used individually or in combination to achieve the desired level of VOC emissions reduction.

Reformulation: Under a reformulation approach, manufacturers would be required to remove as many organic solvents as possible from their products. In most cases, reformulating a product is simpler, quicker and less expensive than attempting to develop an entirely new active ingredient. However, reformulation choices should be evaluated carefully to ensure that the new product is not more harmful than the original. It should be further noted that reformulations must be approved by EPA's Office of Pesticide Programs.

Reducing Fumigant Usage: Reducing the use of fumigants could significantly reduce emissions related to field-applied pesticides. This would require the use of alternative treatment methods or alternative pesticide formulations that are currently available or could be developed. Several states, such as California, Florida and Texas, could benefit from this strategy. One disadvantage of reducing fumigant use is the possibility that the alternative pesticide may require increased application rates and may produce higher VOC emissions.

Alternative Application Methods: The use of alternative application methods and more efficient application equipment are also options for emissions reduction.

Microencapsulation: Microencapsulation is a process in which small particles of the active ingredient are encased to form very small capsules for application. Although this process is not applicable for all active ingredients, the limitations have more to do with economics (Monsanto holds the patent) than with technical feasibility.

IPM: Integrated Pest Management programs use chemical, biological and cultural methods to reduce or control pests at tolerable levels while providing protection

STAPPA/ALAPCO Recommendation

► Air agencies may effectively regulate the application of pesticides by:

- limiting pesticide applications during the ozone season;
- prohibiting the use of solvent-containing fumigants during the ozone season or regulating emissions from fumigation chambers, as the SCAQMD is considering; and
- requiring the lowest VOC-emitting alternative (e.g., microencapsulating AI or using water-based carrier) when alternative techniques are approved.

against hazards to humans, animals and the environment. IPM has been used with varying degrees of success for more than 20 years. Generally, IPM will reduce the use of pesticides and therefore emissions of VOCs from pesticide applications. In certain situations, however, this may not be the case. If, for example, petroleum oils are used in massive amounts to control certain pests, the VOC emissions from the application of these oils may be considerable. Alternatives to petroleum oils, however, may be highly toxic.

Alternative AI and Reducing Use of Crop Oils: The final two techniques are the reduced use of selected active ingredients in formulation and a reduced usage of crop oils. Both of these techniques involve developing alternative formulations or reducing the VOC content of solvents in existing formulations. Use of these techniques could be directed toward selected crops or certain seasons of the year. However, neither of these techniques is expected to significantly reduce VOC emissions.

POTENTIAL NATIONAL EMISSIONS REDUCTION

Potential national VOC emissions reductions range from 20,700 tons per year to 46,400 tons per year, depending on

the control technique used. These reductions are possible if all VOCs are removed from the organic solvents used in liquid pesticides. Although the reductions from each technique are not additive, it is likely that additional reductions could be achieved by implementing more than one control technique. As with national emissions estimates, reduction estimates may have a considerable degree of uncertainty.

Table 3, from EPA's ACT, shows the reduction potential for several of the emissions reduction techniques discussed in this chapter.

COST EFFECTIVENESS

Because of the complex nature of each reduction technique, specific cost effectiveness information is difficult to calculate. However, cost ranges can be estimated. Reformulation is the most expensive technique due to the high costs of developing new compounds, researching their health and environmental effects and registering them with EPA. These costs can be as high as \$100 million for each new compound registered. By contrast, improved application equipment costs range from only \$35 per device to \$50,000.

Microencapsulation would require little or no new costs for application, although manufacturing costs could also be high. The use of IPM techniques could reduce both pesticide use and application costs. No data are available on the costs associated with alternative active ingredient use or reduced use of crop oils.

FEDERAL RULEMAKING AND/OR GUIDANCE DOCUMENTS

Although EPA is not now developing any regulations to limit VOC emissions from pesticide application, the agency is considering including pesticide VOC control in the Federal Implementation Plan for three districts in California.

In March 1993, EPA published an ACT for the control of VOC emissions from the application of agricultural pesticides. The document provides emissions estimates, a list of potential emissions reduction techniques and information on the environmental and cost impacts for each technique. Agencies interested in further information on controlling VOC emissions from pesticide application should review this document in its entirety. The document also reviews existing regulations that apply to the pesticide industry.

❖ For more information on the document, contact Randy McDonald, U.S. Environmental Protection Agency,

Emissions Standards Division (MD-13), Research Triangle Park, NC 27711 (telephone: 919/541-5402).

STATE AND LOCAL CONTROL EFFORTS

All 50 states regulate pesticide use in some manner. California's regulations are the most extensive and tend to be the model for other states. The California regulations require registration, labeling, disclosure of toxic inert ingredients and control of application. They also require that restricted-use pesticides (as designated by EPA and California) be applied by certified commercial or private applicators, including aerial applicators.

Details of the California regulation can be found in Article 4, Chapter 2, Division 7 of the California Food and Agricultural Code. EPA's ACT contains an extensive summary of state pesticide regulations throughout the United States.

The South Coast Air Quality Management District (SCAQMD) is developing Proposed Rule 1422, "Control of Methyl Bromide Emissions from Fumigation Activities." The proposed rule would reduce emissions of methyl bromide by requiring its recovery from commodity chambers after fumigation and discouraging its use in fumigation activities where alternatives are available. An initial workshop on the proposal is scheduled for December 1993; rule adoption is anticipated in 1994.

REFERENCES

1. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. March 1993. *Alternative Control Technology Document - Control of VOC Emissions From the Application of Agricultural Pesticides*. EPA-453/R-92-011.

PESTICIDE APPLICATION

Table 1

Contributions to Nationwide Pesticide Use by the Top Five Pesticide-Using States

State	Percent of Total Pesticide Use	Percent of Total Herbicide Use	Percent of Total Insecticide Use	Percent Contribution of Herbicides to Total State Pesticide Use
Iowa	8.9	10.6	0.7	98.6
Illinois	8.4	9.9	1.0	97.9
Minnesota	5.9	6.9	0.9	97.4
Texas	5.7	5.9	4.8	85.6
California	5.3	3.0	15.7	48.3
TOTAL	34.2	36.3	23.1	—

Table 2

Summary of Estimated Total Active Ingredient Use and Solvent VOC Emissions from Insecticides and Herbicides

	Insecticides ^a	Herbicides ^a	Total ^a
Total nationwide-solvent VOC emissions, tons/yr	3,300	43,100	46,400
Total nonattainment-solvent VOC emissions, tons/yr	800	4,000	4,800
Total nationwide-AI use, tons/yr	43,800	212,000	255,800
Total nonattainment-AI use, tons/yr	10,000	26,000	36,000

^a Data on pesticide use and VOC emissions are based on Resources for the Future's (RFF) data base, which contains data from 1982 to 1984 for insecticides and from 1987 to 1989 for herbicides. According to EPA's ACT, several compounds are no longer in use; also, some states (e.g., California) changed their reporting requirements for pesticides to include both restricted and nonrestricted pesticide applications. Therefore, RFF's data base may be outdated and may not accurately reflect current pesticide use.

Table 3

Summary of Estimated Solvent VOC Emission Reductions^a

Emission Reduction Techniques	Formulation Component	VOC Emissions Due to Solvent, Tons		Estimated Achievable Reduction of Target, Percent
		Nationwide	Non-attainment	
Reformulation	Solvent	46,400	4,800	<100
Fumigants	Fumigants	20,700	4,750	<100
Application efficiency	Solvent	46,400	4,800	<30
Microencapsulation	Solvent	46,400	4,800	<100
IPM	Solvent	46,400	4,800	<33

^aFrom EPA's Alternative Control Technology Document -- Control of VOC Emissions from the Application of Agricultural Pesticides.

Table 4

Summary Table -- Pesticide Application

Affected Facilities	Any agricultural or industrial users of pesticides.
Number of Affected Facilities	Unlimited use across the country.
National Emissions Estimates	Total solvent VOC emissions are estimated to be 46,400 tpy nationwide and 4,800 tpy for nonattainment areas. Total nationwide and nonattainment area fumigant VOC emissions estimates are 20,700 tpy and 4,750 tpy, respectively.
100 TPY Source Size	None of the typical application locations would classify as a 100-tpy emission source. Active ingredient use approaching 550 tpy would be required to reach 100 tpy of solvent emissions from a single pesticide application source.
Potential Emissions Reduction Per Facility	Potential VOC reductions are estimated to range from 30 to 100 percent of the nationwide VOC emissions estimate (13,920 to 46,400 tpy).
Cost Effectiveness	Cost effectiveness data are technique-specific and range from insignificant expenditures (IPM) to \$100 million nationwide (reformulation).
Federal Rulemaking and/or Guidance Documents	EPA is considering pesticide VOC control in three FIPs in California. An ACT was published in March 1993.
State and Local Control Efforts	All states regulate pesticide use in some manner. California requires certification of commercial and private applicators of restricted-use pesticides.
STAPPA/ALAPCO Recommendation	Regulate the application of pesticides by limiting pesticide applications during the ozone season, prohibiting the use of solvent-containing fumigants during the ozone season or regulating emissions from fumigation chambers and requiring the lowest VOC-emitting alternative.

Pharmaceuticals

DESCRIPTION OF SOURCE CATEGORY

Pharmaceuticals include prescription and over-the-counter (OTC) products, (e.g., drugs, enzymes, hormones, vaccines and blood fractions). Broad categories of pharmaceuticals include analgesics, antipyretics and anti-inflammatory agents; antibiotics; antihistamines; central nervous system agents; hormones and synthetic substitutes; medicinal chemicals; narcotics; stimulants; and vitamins. Table 1 provides production data for pharmaceutical products.

Pharmaceuticals typically are manufactured using batch processes. The U.S. Environmental Protection Agency's (EPA's) Control Techniques Guideline (CTG) for the manufacture of pharmaceutical products estimated that there were approximately 800 pharmaceutical manufacturing plants in the United States in 1978. The number of employees per facility varied as follows: 37 percent had fewer than 100 employees, 52 percent employed 100 to 1,000 people and 11 percent had more than 1,000 employees. Approximately 2,700 pharmaceutical manufacturing and retail facilities have been identified based on Standard Industrial Classification (SIC) Code 2834 "Pharmaceutical Preparations."

The total production of pharmaceuticals increased from 65,000 tons in 1964 to 110,000 tons in 1980. Sales increased from \$643 million in 1964 to \$1,153 million in 1980. These numbers do not include finished products, such as tablets and capsules. Sales were distributed as follows: antibiotics at 22 percent, gastrointestinal agents at 27 percent, nervous system stimulants and depressants at 25 percent and vitamins at 17 percent. The Pharmaceutical Manufacturers Association (PMA) reports total product sales for member companies at \$76.5 billion for 1992. PMA also predicts that member sales will reach \$84.9 billion in 1993.

GEOGRAPHIC DISTRIBUTION OF SOURCES

According to EPA, in 1978, nearly 50 percent of all pharmaceutical plants in the United States were located in five states: New York (12 percent), California (12 percent), New Jersey (10 percent), Illinois (5 percent) and Pennsylvania (6 percent). These states also contained the largest plants in the industry. EPA's Region II had 340 plants (28 percent of the total), Region V had 215 plants (20 percent) and Region IX had 143 plants (13 percent).

AVAILABLE CONTROL STRATEGIES

Volatile organic compounds (VOCs) are emitted from a variety of sources within facilities that synthesize pharmaceutical products. EPA has developed draft CTG documents for batch operations and industrial wastewater treatment that address pharmaceutical manufacturing specifically. EPA also has developed a draft CTG for synthetic organic chemical manufacturing industry (SOCMI) reactors and distillation processes that may be applicable to pharmaceuticals. In addition, the proposed Hazardous Organic National Emission Standard for Hazardous Air Pollutants (HON) regulates equipment leak emissions from pharmaceutical manufacturing; however, only carbon tetra-chloride and methylene chloride emissions are addressed. States could apply HON equipment leak requirements to all VOC equipment leaks.

POTENTIAL NATIONAL EMISSIONS REDUCTION

VOC emission reductions will vary from source to source as the mix of equipment components differs. The emissions reduction potential of applying equipment leak requirements to VOCs emitted from pharmaceutical plants is not known.

COST EFFECTIVENESS

Under the proposed HON, it is estimated that the total capital costs for all affected facilities would be \$347 million (1989 dollars) and the total annual costs, excluding the cost savings attributable to equipment leaks, would be \$134 million (1989 dollars) per year. The information on the annual costs of controlling emissions from equipment leaks reveals a cost savings, since avoiding losses from equipment leaks allows products to be saved. The impacts analysis conducted for the proposed HON indicated that the value of the product that is saved is higher than the costs incurred from applying the control required by the rule. Table 2 identifies national control cost impacts for the fifth year.

It is expected that the actual compliance costs of the HON will be less than those shown in the proposal, but it is not possible to quantify the amount. Some operators will duct emissions from several of these emission points to a common control device, upgrade an existing control device, use other less expensive control technologies, implement pollution prevention techniques or use emissions averaging to obtain reductions. All of these options could reduce the estimated costs while achieving the same emissions reductions. However, the effect of such practices on the national costs could not be estimated because the

STAPPA/ALAPCO Recommendation

► Several EPA CTGs and draft CTGs apply to emissions from pharmaceutical operations. These include, among others, batch processes, industrial wastewater treatment, SOCMI reactor and distillation operations and air oxidation. Additionally, the proposed HON addresses equipment leaks and could be used to regulate emissions from pharmaceutical plants.

ability to use any of these practices is highly site-specific and data were not available to estimate how often the lower-cost compliance practices could be used.

FEDERAL RULEMAKING AND/OR GUIDANCE DOCUMENTS

Draft CTGs have been developed for batch processes, industrial wastewater treatment and SOCMI reactor and distillation processes, all of which affect pharmaceuticals. The HON, proposed December 31, 1992, regulates methylene chloride and carbon tetrachloride from equipment leaks at pharmaceutical plants.

EPA also recently initiated development of a pharmaceutical MACT standard.

❖ *For further information on the pharmaceutical standard, contact Randy McDonald, U.S. Environmental Protection Agency, Emission Standards Division (MD-13), Research Triangle Park, NC 27711 (telephone: 919/541-5402).*

STATE AND LOCAL CONTROL EFFORTS

New York's Part 233, Control of Volatile Organic Compound Emissions from Pharmaceutical Manufacturing Processes, applies to all pharmaceutical manufacturing facilities (synthetic or otherwise) statewide with a potential to emit more than 100 tons per year of VOCs. The standards require the use of surface condensers (or equivalent) to control emissions from reactors, extractors, distillation

operations, crystallizers, centrifuges and vacuum dryers. In addition, fugitive emissions from a work area can not be vented to the atmosphere in excess of permissible emission rates.

New York also has requirements applicable to the transfer of VOCs to storage tanks, centrifuges and filters that have an exposed liquid surface, and tank openings. Finally, New York requires the repair of observed leaks.

Pennsylvania's Chapter 129, Part 129.68 and Texas' Regulation V, Subchapter F, Section 115.531 parallel New York's rules.

Virginia's Emission Standards for Synthesized Pharmaceutical Products Manufacturing Operations are also essentially the same as those in New York's rule. However, in addition to specifying operating requirements for surface condensers, Virginia requires that VOC emissions from any reactor, distillation operation, crystallizer, centrifuge, vacuum dryer, process air dryer or production equipment exhaust system be reduced by at least 90 percent by weight.

Subpart T of Parts 218 and 219 of the State of Illinois Rules and Regulations applies to pharmaceutical manufacturing facilities in the Chicago and Metro-East areas. The regulation requires the use of surface condensers to control volatile organic material (VOM) emissions from reactors, distillation units, crystallizers, centrifuges and vacuum dryers used to manufacture pharmaceuticals; other control equipment may be used, provided such equipment will achieve a 90-percent or more reduction in VOM emissions. The rule also contains provisions for the control of VOM emissions from material storage and transfers and in-process tanks.

The South Coast Air Quality Management District's (SCAQMD's) Rule 1103 applies to all pharmaceuticals and cosmetics manufacturing facilities that emit, at the design production rating, more than 15 pounds per day of VOCs. Provisions of Rule 1103 are similar to Virginia's.

Production. Prepared by Pacific Environmental Services, Inc.

REFERENCES

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6. U.S. Environmental Protection Agency. December 31, 1992. *National Air Pollutant Emission Standards for Hazardous Air Pollutants for Source Categories; Organic Hazardous Air Pollutants from the Synthetic Chemical Manufacturing Industry and Seven Other Processes*. Proposed. 57 *Federal Register* 62608.

PHARMACEUTICALS

Table 1

Pharmaceutical Products Production^a

Product	Production (tons)	Year of Data	Change From Previous Year (%)
Miscellaneous Medicinals			
- Dermatological Agents	5,884	1989	-21
- Expectorants and Mucolytic Agents	523	1989	-6
- Gastrointestinal Agents	37,890	1989	-24
- Other	2,637	1988	-31
Analgesics, Antipyretics and Nonhormonal Anti-inflammatory Agents	34,670	1989	62
Antibiotics	19,450	1989	35
Antihistamines	210	1989	-6
Autonomic Agents	490	1988	19
Hormones and Synthetic Substitutes	382	1986	NA
Medicinal Chemicals	143,650	1989	11
Narcotics			
- Opium/Natural Opium Alkaloids	90	1975	70
- Synthetic Opium	3	1975	50
- Cocaine	1	1975	-27
- Synthetic Narcotics	14	1975	26
Other Anti-infectives	9,813	1989	3
Other Central Nervous System Agents			
- Barbiturates/ Hypnotics/Sedatives	838	1986	3
- Skeletal Muscle Relaxants	211	1980	-17
- Tranquilizers	19	1986	-50
- Amphetamines	39	1970	-49
- Anti-Depressants	34	1989	-32
- Caffeine	1,017	1960	NA
- Other Depressants & Stimulants	2,894	1989	-8
Vitamins	21,905	1989	14
Total	282,664		

^a See Reference 1.

Table 2

National Control Cost Impacts in Fifth Year^{a, b}

Emission Points	Total Capital Costs (\$10 ⁶)	Total Annual Costs (\$10 ⁶ /yr)	Average HAP Cost Effectiveness ^c (\$/ton)	Average VOC Cost Effectiveness ^c (\$/ton)
Equipment Leaks	110	(1) ^d	(22) ^d	(11) ^d

^a See Reference 6.

^b These numbers represent estimated values for the fifth year. Existing emission points contribute 84 percent of the total. Emission points associated with chemical manufacturing process equipment built in the first 5 years of the standard contribute 16 percent of the total.

^c Average cost-effectiveness values are determined by dividing total annual costs by total annual emission reduction.

^d Parentheses signify a cost credit or savings.

Table 3

Summary Table - Pharmaceuticals

Affected Facilities	Synthesized pharmaceutical manufacturing facilities. Specific sources include dryers, reactors, distillation units, storage and transfer of VOCs, filters, extraction equipment, centrifuges, crystallizers, pumps, compressors, pressure-relief devices, sampling connection systems, valves, open-ended valves, accumulator vessels and instrumentation systems.
Number of Affected Facilities	Estimated 800 plants nationwide.
Cost Effectiveness	The average cost effectiveness per ton of VOC removed is a credit of \$11 per ton.
Federal Rulemaking and/or Guidance Documents	Subpart H of the HON, proposed December 31, 1992, applies to pharmaceutical manufacturing. EPA is also in the process of publishing CTGs on batch processes and industrial wastewater treatment facilities, which address components of synthetic pharmaceutical manufacturing operations.
State and Local Control Efforts	New York, Pennsylvania, Texas, Virginia, Illinois and SCAQMD require the use of surface condensers to control emissions from reactors, distillation operations, crystallizers, centrifuges and vacuum dryers.
STAPPA/ALAPCO Recommendation	Several CTGs and draft CTGs apply to emissions from pharmaceutical operations, including, among others, batch processes, industrial wastewater treatment, SOCM reactor and distillation operations and air oxidation. Additionally, the proposed HON addresses equipment leaks and could be used to regulate emissions from pharmaceutical plants.

Publicly Owned Treatment Works

DESCRIPTION OF SOURCE CATEGORY

Publicly owned treatment works (POTWs), commonly known as sewage treatment plants, treat domestic sewage and industrial and commercial wastes received primarily through underground sewers.

There are many different types of wastewater systems, reflecting a diversity of sources, environmental conditions and treatment needs. Components of a municipal wastewater system include a sewer collection network, treatment facilities, an outfall and/or disposal facility and residuals management and/or disposal activities. The nature and extent of the systems are a function of the volume of wastewaters to be treated; the types of contaminants in them; and the particular effluent discharge requirements, air emissions limits and residuals management activities specified in permits.

VOCs may be emitted both when wastewaters are transported (in sewer systems and at pumping stations) and when they are treated to remove contaminants. At the POTW, potential emission sources include preliminary treatment and flow measurement devices (e.g., flow equalization basins, screens, grit removal, Parschall flumes); primary treatment units (e.g., settling tanks, dissolved air

flotation); secondary treatment units, including chemical/physical and biological treatment units (e.g., aeration tanks, biological contactors, aerated lagoons); settling basins and secondary clarifiers; filtration systems (e.g., sand filters, mixed-media filters, carbon beds), particularly in backwash cycles; tertiary treatment units (e.g., precipitation tanks, filtration); disinfection processes (e.g., chlorination); and chemical storage tanks.

Emissions vary according to the type of treatment process or operation; the amount of turbulence associated with flow into, through and/or out of the unit; the surface area of exposed wastewaters; and whether or not the treatment unit is heated, aerated/agitated or covered/enclosed.

In addition to the liquid waste treatment unit operations and processes, other associated activities may cause volatile organic compound (VOC) emissions. Such activities include chemical storage; residuals management (i.e., sludge digestion, sludge dewatering, sludge pumping/transport, sludge disposal, carbon regeneration); and effluent aeration that may be required to meet discharge limits specified in the facility's pollution permit.

Emissions from the above POTW activities may be either stack emissions or fugitive emissions. Stack emission sources include combustion exhaust vents from sludge

incinerators or digestion facilities and other ducted wastewater treatment equipment (e.g., dissolved air flotation units, covered activated sludge reactors and sludge handling building blower vents). Fugitive emission sources include large uncovered wastewater or solids management areas, such as settling basins, clarifiers, weirs, compost piles, channels, impoundments and pump stations. Pressurized valves and fittings may also emit fugitive gases. Types of VOCs emitted from POTWs may include oxygenated hydrocarbons, such as aliphatic alcohols and glycols, aliphatic hydrocarbons, halogenated aliphatics, aromatic compounds and petroleum products.

GEOGRAPHIC DISTRIBUTION OF SOURCES

Nationwide, nearly 16,000 POTWs treat approximately 34 billion gallons per day of domestic, commercial and industrial wastewater from hundreds of thousands of users. According to EPA estimates, some 30,000 "significant industrial users" and several hundred thousand other non-domestic (e.g., commercial, institutional and nonsignificant industrial) users discharge to POTWs.

NATIONAL EMISSIONS ESTIMATES

Relatively little information has been published on the extent and effects of air emissions from POTWs. The U.S. Environmental Protection Agency's (EPA's) 1986 Domestic Sewage Study estimated that 0.1 percent of the mass of national emissions of VOCs may come from POTWs. Nationally, 27 POTWs were reported to emit more than 100 tons per year of criteria pollutants. The study estimated national VOC emissions at between 14,300 and 25,300 tons per year. A joint EPA workshop estimated national VOC emissions to be between 29,300 and 35,300 tons per year.

AVAILABLE CONTROL STRATEGIES

One of the primary mechanisms for controlling VOC emissions from POTWs is to implement sewer use/discharge regulations, applicable to all users, that emphasize waste minimization. In particular, industrial pretreatment regulations can reduce levels of VOCs in the wastewater stream by requiring changes in raw materials used, modification of operating practices and processes, preventive maintenance, recycling or segregation of waste streams.

A second approach is to develop and implement emissions reduction programs at the POTWs themselves. Under such programs, facilities could consider incorporating enclosures, add-on controls and/or process

STAPPA/ALAPCO *Recommendation*

► Although POTWs are potentially a large VOC source, little has been done to characterize or control their emissions. Source reduction approaches requiring industrial pretreatment can promote reduced VOC discharges to the wastewater stream and lower processing costs by controlling the VOCs where they are most concentrated.

modifications into their systems. VOC reduction and/or capture and control strategies would also need to be applied to treatment of residuals, including oil phases, condensates and sludges from nondestructive treatment units.

POTENTIAL NATIONAL EMISSIONS REDUCTION

Source reduction programs are the preferred method of control wherever practical. Use of these approaches, in combination with capture and control techniques at POTWs, are believed capable of producing a 50-percent to 90-percent reduction in VOC emissions from POTWs.

FEDERAL RULEMAKING AND/OR GUIDANCE DOCUMENTS

An EPA study is underway to identify and characterize hazardous air pollutant emissions sources and the need for MACT standards for POTWs. The results of the study are expected to be available in the fall of 1993. If necessary, regulations will be promulgated by the fall of 1995.

❖ For more information, contact Eric Crump, U.S. Environmental Protection Agency, Emission Standards Division, Research Triangle Park, NC 27711 (telephone: 919/541-5032).

STATE AND LOCAL CONTROL EFFORTS

The South Coast Air Quality Management District (SCAQMD) is in the process of implementing Rule 1179,

which requires POTWs with a treatment capacity greater than 10 million gallons per day to measure VOCs from the various treatment processes. According to a 1991 estimate, POTW emissions of VOCs in the area range from 0.05 to 3.4 tons per day.

Preliminary data from the Rule 1179 program indicate that 15 of 25 processes contribute 99.3 percent of the total POTW basinwide emissions, which are now estimated to be 0.37 tons per day or 135 tons per year. Additional sampling will be performed to confirm these emissions. In addition, emission factors for each process will be derived. Once the emission factor determinations are completed for each individual process, a rule will be developed requiring a minimum control for VOCs. VOC control for POTWs will consist of enclosing certain processes and venting the contaminated air to conventional control equipment, such as activated carbon, thermal oxidizers, chemical oxidation and biofiltration.

REFERENCES

1. U.S. Environmental Protection Agency, Office of Water. July 1991. *National Pretreatment Program - Report to Congress*.
2. Lake Michigan Air Directors Consortium. April 1993. *Evaluation of Possible Control Measures for Control of Emissions From Publicly-Owned Treatment Works [VOC]*. Draft.
3. U.S. Environmental Protection Agency. February 1986. *Report to Congress on the Discharge of Hazardous Wastes to POTWs*. EPA/530-SW-86-004.
4. U.S. Environmental Protection Agency and the Water Pollution Control Federation. September 1990. *Air Toxic Emissions and POTWs - Workshop Report and Proceedings*.

Table 1

Summary Table - Publicly Owned Treatment Works

Affected Facilities	POTWs nationwide.
Number of Affected Facilities	Approximately 16,000 POTWs.
National Emissions Estimates	14,300 to 35,300 tons per year of VOCs.
100 TPY Source Size	27 POTWs nationwide have criteria pollutant emissions greater than 100 tpy.
Potential Emissions Reduction Per Facility	50 to 90 percent of VOCs.
Federal Rulemaking and/or Guidance Documents	An EPA study is underway; if warranted, federal regulations will be implemented by the fall of 1995.
State and Local Control Efforts	Rule 1179 of the SCAQMD requires measurement of VOCs. A new rule will be developed requiring minimum control of VOCs based on the data obtained from Rule 1179. Control is expected to consist of the use of enclosures to capture emissions and the use of various add-on air pollution control devices.
STAPPA/ALAPCO Recommendation	Although POTWs are potentially a large VOC source, little has been done to characterize or control their emissions. Source reduction approaches requiring industrial pretreatment can promote reduced VOC discharges to the wastewater stream and lower processing costs by controlling the VOCs where they are most concentrated.

Pulp and Paper

DESCRIPTION OF SOURCE CATEGORY

Pulp and paper manufacturing is one of the 10 largest industries in the United States. As the name implies, there are two phases to the industry: the pulping of wood and the production of paper. In the pulping process, wood is reduced to cellulose fibers by dissolving and removing the lignin binder that holds the fibers together in wood. Most mills use chemicals to digest the lignin. The chemicals are recovered by a concentration/combustion process. The level of volatile organic compound (VOC) emissions generated during the pulp manufacturing process varies according to the type of pulping operation, the type of recovery process, the bleaching sequence and the effectiveness of control equipment.

Eighty percent of the pulp produced is from sulfur-related processes: sulfate (kraft), sulfite and neutral sulfite semichemical (NSSC). The other 20 percent is produced by specialized processes.

The kraft, or sulfate, process begins in a digester, where wood chips are cooked, under pressure, in a solution of sodium hydroxide (caustic soda) and sodium sulfide. During digestion, the lignin in the wood is dissolved, freeing cellulose fibers. Upon completion of the digestion, the

pressure from the digester is used to blow the contents into a blow tank. The pressure release and violent transport of the contents of the digester cause the chips to explode and become fiber pulp. Emissions from the digester/blow tank are cooled in a condenser, where water and turpentine are removed. Noncondensables, which contain VOCs and other odorous gases, are treated/controlled or released to the atmosphere.

Pulp, containing black (spent) liquor, is then washed counter-currently in washers to separate the black liquor from the pulp. The cleaned pulp may be further processed by bleaching and forming paper products, or dried and sold as merchant pulp.

Various reactions among kraft mill cooking chemicals generate VOC emissions, including reduced sulfur compounds such as methyl mercaptan (CH_3SH), dimethyl sulfide (CH_3SCH_3), dimethyl disulfide ($\text{CH}_3\text{S}_2\text{CH}_3$) and methanol.

Bleach plant emissions are significantly different from other kraft mill emissions. Bleach plants, which most commonly use chlorine dioxide as the bleaching agent, emit dioxin, furan, chlorinated phenolics and chloroform. These compound emissions, excluding chloroform, are located in the wastewater. Mills making products with a

STAPPA/ALAPCO Recommendation

► State and local agencies should implement the MACT standards from the integrated rule for pulp and paper, expected to be published later this year.

totally chlorine-free process would not be subject to hazardous air pollutant (HAP) limits for these compounds because these compounds are not formed, or are formed in very small quantities, when chlorine compounds are not used. Currently, there are no kraft mills using a totally chlorine-free bleach process.

Malodorous VOC emissions result from distribution and treatment of pulp and paper mill wastewater. These emissions can occur from liquid surfaces in open channel flow, sewer manholes, sewer vents, pumping stations and wastewater treatment facilities. Major chemical constituents that produce odors from pulp and paper mill effluents are VOCs, sulfur and nonsulfur compounds. Mercaptans formed during the cooking process are released into digester condensate waters and are emitted during transport or treatment. Overloaded or incompletely mixed biological waste treatment facilities with sludge accumulation or inadequately dissolved oxygen levels can also be the source of odorous gases, such as organic acids formed by anaerobic fermentation.

Sulfite and NSSC pulping processes have similar types of unit operations. Unlike most kraft mills, sulfite mills commonly use hypochlorites to bleach their pulp, which generally leads to greater chloroform emissions. The cooking process at sulfite mills also differs from that used at kraft mills, producing somewhat different emissions.

GEOGRAPHIC DISTRIBUTION OF SOURCES

Because of economic considerations, large pulp and paper mills are usually located near the source of wood. As a result, many facilities are located in the southeast and northwest sections of the United States. Other major pulp and paper mills are located in Wisconsin and Maine.

NATIONAL EMISSIONS ESTIMATES

The U.S. Environmental Protection Agency (EPA) estimates the nationwide VOC emissions from this industry at 830,000 megagrams (817,000 tons). The pulp and paper industry is currently conducting a major test program to obtain additional data on emissions.

AVAILABLE CONTROL STRATEGIES

Several techniques are available to control emissions from pulp and paper mills. Since Maximum Achievable Control Technology (MACT) limitations have not been established, EPA has not recommended control techniques. Some of the control options available for consideration are as follows: collecting and directing pulping area sources to a combustion device; venting bleaching sources to a scrubber; changing bleaching techniques; and steam stripping wastewater streams.

POTENTIAL NATIONAL EMISSIONS REDUCTION

EPA estimates that the potential national VOC reductions from the pulp and paper industry is approximately 715,000 megagrams (704,000 tons) or 86 percent.

COST EFFECTIVENESS

While little cost-effectiveness information is available for controlling VOCs, cost data exist for controlling HAPs. The cost effectiveness of MACT controls using the air control option without process changes is estimated to range from \$2,070 to \$2,780 per megagram (\$2,040 to \$2,740 per ton) of HAPs removed. For the same option with process changes, the cost effectiveness ranges from \$7,870 to \$8,590 per megagram (\$7,750 to \$8,450 per ton) of HAPs removed.

FEDERAL RULEMAKING AND/OR GUIDANCE DOCUMENTS

EPA is currently preparing an integrated rule for the pulp and paper source category that incorporates both the Clean Water Act Effluent Guidelines and the Clean Air Act MACT Standards for HAPs (Section 112). The rule is expected to be published later this year.

❖ For further information, contact Penny Lassiter, U.S. Environmental Protection Agency, Emission Standards Division (MD-13), Research Triangle Park, NC 27711 (telephone: 919/541-5396).

STATE AND LOCAL CONTROL EFFORTS

Because most pulp and paper mills are located in attainment areas, there has been little activity to date to control VOCs from these facilities.

REFERENCES

1. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. April 1981. *Control Techniques for Sulfur Oxide Emissions from Stationary Sources*. Second Edition. EPA-450/3-81-004.
2. U.S. Environmental Protection Agency, Office of Technology Transfer. October 1976. *Environmental Pollution Control - Pulp & Paper Industry*. Part 1 - Air. EPA-625/7-76-001.
3. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. May 19, 1993. *Public Meeting for the Proposed Pulp and Paper Integrated Rule: Clean Water Act Effluent Guidelines and Clean Air Act MACT Standards*.
4. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. April 1993. *Pulp, Paper, and Paperboard Industry - Background Information for Proposed Air Emission Standards: Manufacturing Presses at Kraft, Sulfite, Soda, and Semi-Chemical Mills*.

Table 1

Summary Table - Pulp and Paper

Affected Facilities	Pulp and paper mills emitting VOCs.
Number of Affected Facilities	Approximately 900.
National Emissions Estimates	830,000 megagrams (817,000 tons) of VOCs
Potential National Emissions Reduction	715,000 megagrams (704,000 tons) of VOCs
Cost Effectiveness	Cost-effectiveness estimates range from \$2,070 to \$8,590 per megagram (\$2,040 to \$8,450 per ton) of HAP removed.
Federal Rulemaking and/or Guidance Documents	EPA is developing an integrated Rule for Effluent Guidelines under the Clean Water Act and MACT standards for HAPs under Section 112 of the Clean Air Act, which will be published later this year.
STAPPA/ALAPCO Recommendation	Implement the MACT standards for the integrated pulp and paper rule.

Rule Effectiveness Improvement

INTRODUCTION

Rule effectiveness (RE) improvement refers to an improvement in the implementation of a regulation. An RE improvement may take several forms, ranging from more frequent and in-depth training of inspectors to larger fines for sources that do not comply with a given rule. RE improvements are an important issue in areas that have already adopted reasonably available control technology for many of their larger sources.

The purpose of an RE improvement is to give state and local agencies additional means for achieving actual reductions for their State Implementation Plans (SIPs). Title I of the Clean Air Act identifies RE improvements as one of the measures that can be used to meet the 15-percent volatile organic compound (VOC) reduction requirements by November 15, 1996.

DETERMINATION OF IMPROVEMENTS

The establishment of the original RE (base RE before improvement) can be accomplished by four methods in accordance with a May 26, 1993 U.S. Environmental Protection Agency (EPA) memorandum on *Calculation of Rule Effectiveness for Emissions Inventories* and EPA's guid-

ance document on *Guidelines for Estimating and Applying Rule Effectiveness for Ozone/CO SIP Base Year Inventories* (EPA-452/R-92-010). These four methods include the 80-percent default, the questionnaire approach, the Stationary Source Compliance Division (SSCD) Protocol Study and the alternative RE method.

80-Percent Default: This method uses an across-the-board presumption of 80 percent for all sources.

Questionnaire Approach: This approach uses an EPA questionnaire to determine a category-specific RE value for both point and area sources.

SSCD Protocol Study: For this method, a study specific to a category is conducted in accordance with the procedure developed by SSCD.

Alternative RE Method: Under this option, state and local agencies are given greater flexibility in designing an alternative method. An addendum to the November 1992 guidance outlines information state and local agencies should consider in designing alternative RE methods, including:

- General available overall capture and control efficiency for the type of equipment being assessed;
- Any stack test/performance evaluations;

- The manufacturer's rated capture and control efficiency; and
- The kinds of activities that affect determination of day-to-day performance, which are listed in the questionnaires contained in the guideline document (e.g., ease of determining compliance, type of control equipment, frequency and quality of inspections and level of training of inspectors).

In addition, the alternative RE method must also adhere to the following basic requirements outlined in the guidelines:

- Follow the sampling strategy (i.e., 80 percent of total pollutant-specific emissions should be covered by the questionnaire and all categories representing 5 percent or greater should use the questionnaire); and
- Provide rationale for additions or deletions to the questionnaire.

To estimate creditable emissions reductions from RE improvements, state and local agencies require a methodology to quantify the predicted RE increase. The methodology must measure the impact of specific improvement measures available to a state or local agency. In the absence of any compliance or emissions data to quantitatively assess RE improvement measures, EPA's Ozone/Carbon Monoxide Programs Branch developed an RE matrix. The RE matrix is based on a questionnaire that EPA used to estimate base rule effectiveness for source categories. The following principles guided the development of the matrix:

- All state and local agencies should be guaranteed at least 80 percent base RE;
- State and local agencies with an RE well above the 80-percent default should receive more emissions reduction credits for an RE improvement than agencies near the 80-percent default;
- RE improvements should be documented in a permit or in a SIP revision; and
- One-hundred-percent RE is achieved in cases of direct determination of emissions or elimination of VOCs or other pollutants through an irreversible process change.

The matrix is divided into 13 categories representing the range of activities and conditions that influence rule effectiveness. The 13 categories are:

- Training of Plant Operators
- Inspector Training

STAPPA/ALAPCO Recommendation

► State and local agencies could obtain additional VOC reduction credits by improving rule effectiveness beyond the presumptive 80-percent level set by EPA.

- Educational Opportunities for Source
- Procedures for Operation and Maintenance of Control and/or Process Equipment
- Clarity of Testing Procedures and Schedules
- Rule Effectiveness Evaluation Program
- Monitoring
- Type of Inspection
- Administrative Authority - Prison
- Administrative Authority - Fines
- Administrative Authority - Citations
- Media Publication of Enforcement Action
- Follow-up Inspections

The matrix includes subcategories for six of these categories. Control measures, which are the most specific item in the matrix, are arranged in descending order, with the first measure having the most significant impact on RE.

After developing the matrix, EPA used the Delphi Method to assign weights to the various categories, subcategories and measures. The Delphi Method relies on a panel of experts to quantify an inherently unquantifiable topic. Seven experts from state regulatory agencies and EPA were invited to serve on the panel. Panel members reviewed the matrix several times, assessing the relative values of each category, subcategory and measure. After assigning these relative values, they assigned a weight to each category on a scale of 1 to 30 and distributed the weight among the subcategories, where applicable. The panel members also assigned weights to each measure on a scale of 1 to 10.

The first (and most significant) measure in each category and subcategory automatically received a 10 to ensure consistency among the most effective measures. The measures at and below the 80-percent rule effectiveness level automatically received a 1. This ensured that states will not receive additional credits for RE improvements below the 80-percent level.

The first category in the matrix is "Training of Plant

Operators," which is designated by "A." The Delphi Panel assigned it a weight of 20, or "G(A)=20." The weight was distributed among subcategories 1, 2, and 3 in the following manner: G(A1)=9, G(A2)=7, and G(A3)=4. The panel also assigned weights from 1 to 10 to each measure within the subcategories. For example, the five measures of subcategory G(A1), which gauges operator training courses, have weights of 10, 8, 5, 2, and 1.

The reviewer must use the weights in the matrix to calculate a Rule Effectiveness Raw Score (RERS) for a given source category. The RERS is then used to determine the RE improvement, and to determine a final RE after the improvement has been implemented. The final RE is a percentage that the reviewer uses to develop the future emissions inventory for a given category in a nonattainment area.

Equations 1 through 4 below illustrate how a regulatory agency would calculate the RERS and use it to determine the RE improvement, the final RE and the emissions reduction credits.

EQUATION 1

$$RERS = \sum_{s=1}^n \{ G(x_s) \sum_{t=1}^m [F(t, G(x_s), f) \times z(t, f)] - [F(t, G(x_s), y(t, o))] \}$$

G(x)	=weight assigned to category x
G(x _s)	=weight assigned to subcategory s of category x
F(t, G(x _s))	=weight assigned to measure t of subcategory s
F(t, G(x _s), o)	=value of measure t of subcategory s before RE improvement is implemented
F(t, G(x _s), f)	=value of measure t of subcategory s after RE improvement is implemented
Y(t, o)	=emissions corresponding to facilities implementing measure t as a percentage of total emissions from the source category before improvement is implemented, where applicable, or 1
z(t, f)	=emissions corresponding to facilities implementing measure t as a percentage of total emissions from the source category after improvement is implemented, where applicable, or 1

EQUATION 2

$$RERS(i) = [100 - RE(o)] \times RERS/RERS(max)$$

EQUATION 3

$$RE(f) = RE(o) + RE(i)$$

EQUATION 4

$$ERC = [RE(f) \times I] - [RE(o) \times I]$$

RERS(max)	=maximum RERS (from sum of differences between minimum and maximum values of the measures in each category and subcategory)
RE(o)	=original RE (base RE) before RE improvement
RE(i)	=RE improvement over base RE
RE(f)	=final RE after RE improvement
I	=current emissions inventory for the stationary source category
ERC	=total emissions reduction credits from RE improvements

FEDERAL RULEMAKING AND/OR GUIDANCE DOCUMENTS

EPA's Ozone/CO Programs Branch has developed a draft guidance document on rule effectiveness improvement credits and is expected to publish this document by the fall of 1993.

❖ For further information, contact your EPA Regional Office or John Silvasi, U.S. Environmental Protection Agency, Air Quality Management Division (MD-15), Research Triangle Park, NC 27711 (telephone: 919/541-5666).

REFERENCES

1. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. May 26, 1993. "Calculation of Rule Effectiveness for Emissions Inventories." Memorandum.
2. U.S. Environmental Protection Agency. November 1992. *Guidelines for Estimating and Applying Rule Effectiveness for Ozone/CO SIP Base Year Inventories*. EPA-452/R-92-010.
3. TRC Corporation (Church, S. and D. Zimmerman). April 1993. *Rule Effectiveness: Integration of Inventory, Compliance and Assessment Applications*. Draft.

Shipbuilding and Ship Repair

DESCRIPTION OF SOURCE CATEGORY

The shipbuilding and ship repair industry consists of facilities that build and repair ships. Operations included under this category are repainting, conversion and alteration of ships. A ship is defined as any marine or freshwater vessel used for military or commercial operations, including self-propelled vessels and those towed by other craft (such as barges). This includes, among others, all military vessels, commercial cargo and passenger (cruise) ships, ferries, barges, tankers, container ships, patrol and pilot boats and dredges. Pleasure craft, however, are not included in this category.

There are approximately 437 facilities (i.e., shipyards) involved in the construction and repair of ships. As of October 1, 1992, there were 16 active privately owned shipyards capable of building naval and commercial ships over 1,000 tons. An individual shipyard may employ from 10 to 26,000 people.

GEOGRAPHIC DISTRIBUTION OF SOURCES

Shipyards are located in 34 states along the east coast and Gulf coast; in addition, there are shipyards at some inland locations along the Mississippi River and its tributaries, as

well as around the Great Lakes. Many small bargeyards are concentrated in Louisiana and Texas.

NATIONAL EMISSIONS ESTIMATES

Although no national emissions estimates are available, the U.S. Environmental Protection Agency's (EPA's) draft Control Techniques Guideline (CTG) for the shipbuilding and repair industry discusses eight model shipyards. Four of the shipyards are involved primarily in construction and four focus on ship repairs. Table 1 includes volatile organic compound (VOC) emissions estimates for these facilities.

AVAILABLE CONTROL STRATEGIES

Strategies to reduce VOC emissions include switching from high-solvent coating formulations to waterborne formulations, decreasing the solvent-to-solids ratio, using add-on control devices to recover or destroy VOC emissions and changing work practices along with instituting a solvent management system.

Replacement of High-Solvent Coatings with Waterborne Formulations: Although most waterborne

coatings still contain solvents, the addition of water to formulations allows for a reduction in the percentage of solvents needed. However, waterborne coating formulations may not perform well enough to be used in the harsh environmental conditions of marine service.

Decreasing Solvent-to-Solids Ratio: Decreasing the solvent-to-solids ratio in coatings to reduce VOC emissions has been successful in other industrial coating operations. Normally, as the solvent content per unit volume of coating decreases, the viscosity increases. Spraying equipment is sensitive to viscosity changes and more viscous coatings may not spread and cure properly on the coated surface. The viscosity of a coating may be reduced by heating the coating immediately before spraying. Paint heaters are used in at least two shipyards. However, shipbuilders in colder climates have reported that applying heated paint to cold surfaces in the winter can result in cracking and other problems because of the rapid cooling of the hot paint after it is applied to a cold surface.

Use of Add-on Controls: Add-on controls include thermal and catalytic incinerators and carbon adsorption systems. Incinerators destroy VOC emissions, converting them primarily to carbon dioxide and water. Carbon adsorbers collect VOCs on an activated carbon bed. The VOCs are recovered when the carbon bed is stripped with steam or hot air; recovered VOCs are then discarded or destroyed.

No shipyards currently use add-on controls, although these devices could potentially control VOC emissions. Although there is currently no commercially available technology for enclosing outside areas to capture emissions from painting operations, add-on controls may be applicable for storage tanks in ships and painting operations inside buildings within shipyards.

Changing Work Practices/Installing Solvent Management Systems: Changing work practices and installing a solvent management system have been used to reduce VOC emissions from cleaning operations. Work practices can be reevaluated and modified to reduce the amount of solvent used and allowed to evaporate. Examples include wiping a surface by hand with a solvent-laden rag instead of spraying the surface with a cleaning solvent, saving solvents for reuse and reducing evaporative emissions by improving handling practices. The Alternative Control Technology (ACT) document for industrial cleanup solvents currently being developed by EPA identified a solvent accounting program. The first element consists of tracking the use, fate and cost of all cleaning solvents. The second element calls for a solvent management system to reduce or control emissions based on the information about the use, fate and cost of cleaning solvents. Solvent usage can also be reduced by employing special solvent dispensers for wiping a sur-

face with rags and disposing the rags in covered containers. Also, emptying the paint from a spray gun prior to cleaning (i.e., spraying the equipment dry) and cleaning equipment promptly after use (i.e., not allowing the paint to dry in or on the equipment) both reduce the amount of solvent required.

An alternative technology for coating marine vessels involves flame-spraying finely powdered thermoplastics. The U.S. Coast Guard has used this technology on several boats and is considering using it to coat buoys and barges.

POTENTIAL NATIONAL EMISSIONS REDUCTION

It is estimated that between 50 and 55 percent of the VOCs used as solvents in marine paints are also hazardous air pollutants (HAPs), which must be controlled by the Maximum Achievable Control Technology (MACT) standard for shipyards. The reformulation of coatings to higher-solids and waterborne coatings appears to provide the most promising reduction potential for VOC and HAP emissions. Paint heaters (as a viscosity-reduction technique that would minimize the solvent needed for thinning) and add-on controls for spray booths appear to be technically infeasible and/or too costly. None of the shipyards surveyed for the MACT standard uses add-on control devices.

COST EFFECTIVENESS

Depending on the type of model shipyard, EPA estimates that the cost effectiveness of controlling VOCs ranges from \$1,200 to \$1,600 per ton of VOC removed. The San Diego County Air Pollution Control District has issued a tactic evaluation for controlling VOC emissions from marine coatings that estimates a cost-effectiveness range of a savings of \$4.00 per pound to a cost of up to \$6.40 per pound of VOCs reduced (based on an economic analysis by the California Air Resources Board for architectural specialty category coatings). EPA has estimated cost effectiveness to be approximately \$0.75 per pound. This estimate is based on VOC emissions reductions that would be achieved by reformulating coatings and by reducing VOC evaporation during clean-up. In addition, there may also be some limited applications for add-on control devices where finishes are oven-cured or baked.

FEDERAL RULEMAKING AND/OR GUIDANCE DOCUMENTS

EPA is currently developing a National Emission Standard for Hazardous Air Pollutants (NESHAP) under Section 112 of the Clean Air Act for the shipbuilding and ship repair industry. The agency also is developing a separate

CTG document for the industry, under Section 183 of the Clean Air Act. Since HAP emissions are a subset of VOC emissions from this category, it is important to consider the interrelationships between HAPs and VOCs in developing control strategies. Therefore, the NESHAP and CTG are being developed concurrently in a single project. The actions are expected to be published in draft form for public comment in mid-1994 and finalized in mid-1995.

❖ *For more information on these regulations, contact Mohamed Serageldin, U.S. Environmental Protection Agency, Emission Standards Division (MD-13), Research Triangle Park, NC 27711 (telephone: 919/541-2379).*

STATE AND LOCAL CONTROL EFFORTS

State and local agencies with existing regulations that affect VOC emissions from the marine coating of ships include Virginia, Connecticut, Louisiana, Maine, Washington, Wisconsin, California, as well as local California air districts, such as the Bay Area Air Quality Management District, the South Coast Air Quality Management District and the San Diego County Air Pollution Control District.

The California and Louisiana regulations are the only ones that address the shipbuilding and ship repair industry specifically. California and the local California air districts listed above have regulations specifically limiting emissions and specifying maximum VOC contents for paints typically used in specific applications (e.g., as antifoulants).

The San Diego County Air Pollution Control District has estimated that VOC emissions will be reduced by 22 percent as a result of regulations requiring that the VOC content of all marine vessel coatings be lowered and that clean-up of coating application tools and equipment be conducted in closed systems, using materials with a lower VOC content. The reduction is calculated to be 0.5 tons per day (tpd) of VOC emissions from an estimated daily release of 2.29 tpd from marine vessel coating operations. Full implementation is expected by 1995. The 22-percent reduction estimate that San Diego derived results from 24-percent control efficiency applied to 98 percent of the source category emissions and assumes a 95-percent compliance rate. Other areas may need to adjust their estimates and compliance rates based on local conditions.

Louisiana enforces VOC limits for its shipyards by estimating facility emissions from material safety data sheets (MSDSs) for paints and comparing those emissions with the maximum allowable VOC contents defined by the regulation. Louisiana uses VOC limits similar to the limits for various specialty marine coatings adopted by Califor-

STAPPA/ALAPCO Recommendation

► Agencies can reduce emissions from shipbuilding and repair operations by requiring enhanced application techniques, such as High-Volume Low-Pressure (HVLP) spray or other alternatives that achieve a minimum of 65-percent transfer efficiency. Agencies should consider CARB's suggested general limit for marine coatings of 340 grams per liter (g/l), which became effective on September 1, 1992, however, some specialty coatings may require higher VOC limits.

nia. A comparison of the VOC limits in the California and Louisiana regulations appears in Table 2.

Connecticut and Wisconsin do not specifically regulate VOC emissions from shipyards, but require coating manufacturers to substitute lower-reactive solvents using the old "California Rule 66" to delay the formation of ozone.

Maine and the Puget Sound Air Pollution Control Agency have general provisions that allow for the regulation of VOC emissions. Maine requires new sources to use Best Available Control Technology (BACT), while the Puget Sound Air Pollution Control Agency restricts or prohibits painting operations when wind speeds exceed 20 miles per hour.

REFERENCES

1. U.S. Environmental Protection Agency. June 25, 1993. *Shipbuilding and Ship Repair Industry - Background Information for National Emissions Standards for Hazardous Air Pollutants (NESHAP)*. Preliminary Draft.
2. U.S. Environmental Protection Agency. June 25, 1993. *Shipbuilding and Ship Repair Industry - Background Information for Control Techniques Guidelines (CTG)*. Preliminary Draft.
3. DuPont Magazine. "A Coat for All Seasons." Wilmington, DE. pp. 22-25.

Table 1

VOC Emissions Estimates for Model Shipyards^{a,b}

Yard Type	Construction				Repair			
Size Classification	Extra Small	Small	Medium	Large	Extra Small	Small	Medium	Large
Average total coating usage, l/yr (gal/yr)	27,785 (7,340)	70,988 (18,753)	158,726 (41,931)	510,560 (134,876)	34,436 (9,097)	70,511 (18,627)	131,228 (34,667)	453,718 (119,860)
Average total solvent usage, l/yr (gal/yr)	14,415 (3,808)	10,845 (2,865)	43,532 (11,500)	162,132 (42,831)	10,224 (2,701)	1,893 (500)	20,562 (5,432)	23,091 (6,100)
Percent used for thinning	50	40	20	50	20	3	20	20
Percent used for cleaning	50	60	80	50	80	97	80	80
VOC emissions by coating category, kg/yr (tons/yr)								
SPECIALTY:								
Antifoulant	400 (0.5)	1,100 (1.2)	2,500 (2.7)	7,900 (8.7)	3,000 (3.3)	6,100 (6.7)	11,300 (12.5)	39,000 (43.2)
Inorganic zinc	2,300 (2.5)	5,800 (6.4)	13,000 (14.3)	41,700 (45.9)	100 (0.1)	300 (0.3)	500 (0.6)	1,700 (1.9)
Other specialty	1,200 (1.3)	3,000 (3.3)	6,600 (7.3)	21,300 (23.5)	1,700 (1.9)	3,500 (3.9)	6,600 (7.3)	22,800 (25.1)
GENERAL USE:								
Alkyd-based	2,200 (2.4)	5,600 (6.1)	12,500 (13.7)	40,100 (44.2)	400 (0.4)	800 (0.9)	1,500 (1.6)	5,200 (5.7)
Epoxy-based	5,300 (5.9)	13,600 (14.9)	30,300 (33.4)	97,500 (107.5)	7,600 (8.3)	15,500 (17.1)	28,800 (31.8)	99,700 (109.9)
VOC emissions by solvent category, kg/yr (tons/yr)								
Thinner	6,000 (6.7)	3,600 (4.0)	7,300 (8.1)	68,000 (75.0)	1,700 (1.9)	50 (0.1)	3,500 (3.8)	3,900 (4.3)
Cleaning ^c	2,100 (2.3)	1,900 (2.1)	10,200 (11.3)	23,800 (26.2)	2,400 (2.6)	500 (0.6)	4,800 (5.3)	5,400 (6.0)
TOTAL VOC EMISSIONS, kg/yr (tons/yr)								
	19,500 (21.6)	34,600 (38.0)	82,400 (90.8)	300,300 (331.0)	16,900 (18.5)	26,800 (29.6)	57,000 (62.9)	177,700 (196.1)

^a See Reference 2.

^b All numbers in this table are independently rounded; as a result, metric and English units may not agree precisely.

^c Cleaning emissions are estimated assuming 65 percent of all cleaning solvents used are collected and disposed of as a hazardous waste.

Table 2
**VOC Limits for the Shipbuilding and Ship Repair Industry
in California and Louisiana^a**

Coating Category	California VOC Limits				Louisiana VOC Limits	
	g/l		lb/gal		g/l	lb/gal
	9/92	9/94	9/92	9/94	7/91	
General limits	340	340	2.8	2.8	420	3.5
Antenna	530	340	4.4	2.8	490	4.1
Antifoulant	400	400	3.3	3.3	440	3.7
Heat-resistant	420	420	3.5	3.5	420	3.5
High-gloss	420	420	3.5	3.5	420	3.5
High-temperature	500	500	4.2	4.2	650	5.4
Inorganic zinc	650	340	5.4	2.8	650	5.4
Low-activation interior	420	420	3.5	3.5	490	4.1
Military exterior	340	340	2.8	2.8	420	3.5
Navigational aids	550	340	4.6	2.8	420	3.5
Pretreatment wash primer	780	420	6.5	3.5	780	6.5
Repair and maintenance thermoplastics	550	340	4.6	2.8	650	5.4
Wire spray sealant	610	610	5.1	5.1	648	5.4
Specialty interior	340	340	2.8	2.8	420	3.5
Special marking	490	420	4.1	3.5	490	4.1
Tack coat	610	610	5.1	5.1	610	5.1
Undersea weapons systems	340	340	2.8	2.8	—	—
Extreme high-gloss	N/A	N/A	N/A	N/A	490	4.1
Metallic heat-resistant	N/A	N/A	N/A	N/A	530	4.4
Anchor chain asphalt (TT-V-51)	N/A	N/A	N/A	N/A	620	5.2
Wood spar varnish (TT-V-119)	N/A	N/A	N/A	N/A	492	4.1
Dull black finish (DOD-P-15146)	N/A	N/A	N/A	N/A	444	3.7
Tank coatings (DOD-P-23236)	N/A	N/A	N/A	N/A	420	3.5
Potable water tank coating (DOD-P-23236)	N/A	N/A	N/A	N/A	444	3.7
Flight deck markings (DOD-C-24667)	N/A	N/A	N/A	N/A	504	4.2
Vinyl acrylic top coats	N/A	N/A	N/A	N/A	648	5.4
Antifoulants on aluminum hulls	N/A	N/A	N/A	N/A	550	4.5
Elastomeric adhesives (with 15 wt % rubber)	N/A	N/A	N/A	N/A	730	6.1

^aLimits expressed in units of g/l and lb/gal of coating as applied, less water and exempt solvent

Table 3
Summary Table -- Shipbuilding and Ship Repair

Affected Facilities	Shipbuilding and ship repair shipyards.				
Number of Affected Facilities	Approximately 437 facilities nationwide.				
VOC Emissions Range Per Facility		Extra Small	Small	Medium	Large
	Annual VOC Emissions	<25 tons	25 tons to 50 tons	50 tons to 100 tons	100 tons or more
100 TPY Source Size	Only model facilities classified as large construction and large repair shipyards.				
Federal Rulemaking and/or Guidance Documents	EPA is currently developing a NESHAP and a CTG for controlling HAP and VOC emissions from the shipbuilding and ship repair industry.				
Cost Effectiveness	Depending on the type of model shipyard, EPA estimates the cost effectiveness of controlling VOC emissions ranges from \$1,200 to \$1,600 per ton of VOCs removed. San Diego estimates that cost effectiveness ranges from a savings of \$4.00 per pound (\$8,000 per ton) to a cost of \$6.40 per pound (\$12,800 per ton) of VOCs removed.				
State and Local Control Efforts	<p>Although various state and local agencies have regulations that affect VOC emissions from shipbuilding and repair, only California and Louisiana have regulations that apply specifically to the industry.</p> <p>California limits maximum VOC contents of shipyard coatings.</p> <p>Louisiana defines the maximum allowable VOC content by regulation and compares the limits to MSDS sheets.</p> <p>Connecticut and Wisconsin require lower reactive solvents to delay formation of ozone.</p> <p>Maine requires the use of BACT for new sources.</p> <p>Puget Sound Air Pollution Control Agency restricts painting in high winds.</p>				
STAPPA/ALAPCO Recommendation	Require enhanced application techniques (e.g., HVLP spray), achieving a minimum 65-percent transfer efficiency; consider CARB limit of 340 g/l for marine coatings.				

Stage II Vapor Recovery

DESCRIPTION OF SOURCE CATEGORY

Stage II vapor recovery applies to all facilities that dispense gasoline to motor vehicle fuel tanks from stationary storage vessels. This includes both public (retail) and private facilities. Miscellaneous retail outlets, such as conventional service stations, convenience stores and mass merchandisers or "pumpers" are included in this category, as are parking garages and other similar facilities that sell gasoline to the public.

Private facilities include those that dispense gasoline to government vehicles (i.e., federal, state and local government vehicles and military vehicles); fleet vehicles (e.g., auto rental and utility company vehicles, taxis, school buses); and trucking and local service vehicles. Private facilities that exclusively refuel farm equipment are not included in this category.

GEOGRAPHIC DISTRIBUTION OF SOURCES

Based upon 1990 estimates, there are approximately 420,000 gasoline dispensing facilities nationwide, divided equally between public and private facilities. These facilities are distributed widely throughout the country, with regional distribution roughly related to population density.

Private facilities are generally very small, with approximately 90 percent of them excluded when the typical exemption level of 10,000 gallons per month is applied.

In 1990, gasoline consumption nationwide totaled more than 116 billion gallons. The U.S. Environmental Protection Agency's (EPA's) Technical Guidance: Stage II Vapor Recovery Systems for Control of Vehicle Refueling Emissions at Gasoline Dispensing Facilities includes data on consumption by state and by month for 1990. The Clean Air Act Amendments of 1990 require Stage II vapor recovery in all Moderate and above ozone nonattainment areas. According to EPA's technical guidance document, 50.3 billion gallons, or 43 percent of nationwide consumption, were dispensed in such areas in 1990.

NATIONAL EMISSIONS ESTIMATES

Factors that influence emissions from vehicle refueling include fuel volatility (i.e., Reid Vapor Pressure), the temperature of the dispensed gasoline and the temperature differential between the dispensed gasoline and the vehicle tank. Each of these factors tends to vary according to the time of year and the geographic location of the dispensing facility. EPA's technical guidance document includes

tables that can be used to calculate an emission factor specific to each state at various times of the year.

A nationwide emissions estimate can be derived using data on annual gasoline consumption (in 1990, 116 billion gallons nationwide, including 50.3 billion gallons in Moderate and above ozone nonattainment areas) and a nationwide average emission factor (1,340 micrograms [mg] of volatile organic compound [VOC] per liter of gasoline dispensed, according to Table 3-8 of the technical guidance document). These values yield a nationwide VOC emissions estimate of 650,000 tons and a nonattainment area estimate of 280,000 tons.

AVAILABLE CONTROL STRATEGIES

Stage II vapor recovery technology has been in use in California since the early 1970s. As the technology has evolved over the years, other geographic areas have also implemented Stage II requirements. Stage II technology consists of capturing emissions displaced from the vehicle tank during refueling and routing these vapors back to the underground tank through vapor piping.

Stage II systems fall into two major categories: vapor balance systems and vacuum-assisted systems. The vapor balance system uses a boot around the dispensing nozzle to capture vapors displaced during refueling. The balance system uses displacement forces between the underground tank and the vehicle tank as the driving force for capturing and routing vapors to the underground tank and requires a tight fit at the vehicle/fillneck interface to capture vapors.

The vacuum-assisted system uses a vacuum-producing device to assist in capturing vapors and transferring them to the underground tank. A vacuum applied to the vapor return line can minimize or eliminate vapor loss; if the vacuum applied to the vapor return line results in a negative pressure at the nozzle/fillneck interface, a greater volume of air/vapor mixture is returned to the tank than the volume of liquid that was dispensed. In this case, a vapor processor (usually a thermal oxidizer) is used to control these excess vapors. This equipment typically has a boot around the nozzle but does not require a tight fit at the fillneck. The most recent advances include a "bootless" nozzle that has a double-walled spout that collects vapors between the inner and outer layers. Many vacuum-assisted systems require a pressure vacuum vent on the underground tank vent to maintain the system within design pressures.

POTENTIAL NATIONAL EMISSIONS REDUCTION

The level of emissions reduction that can be achieved with Stage II vapor recovery depends more on the exemption

STAPPA/ALAPCO Recommendation

► Stage II rules have already been developed by and effectively implemented in a number of jurisdictions. Forthcoming state and local rules for Stage II should be designed to yield a 95-percent level of control efficiency, in that this level is generally accepted as being achievable. Further, Stage II programs should include requirements for equipment to undergo the California certification process; such a requirement is an effective way to minimize the need for independent testing or certification of equipment. Exemptions should be limited to facilities with a throughput of less than 10,000 gallons per month. While the Clean Air Act allows exemptions for independent stations with a throughput of up to 50,000 gallons per month, numerous areas have implemented a 10,000-gallon per month limit without significant adverse economic impact. Finally, inspections should be conducted on a semi-annual basis, at least in the initial years, in that inspections at this frequency are a cost-effective means of assuring that anticipated reductions are achieved. Areas should plan on one inspector per 1,000,000 of population to implement a semi-annual inspection program.

Although the court-ordered January 1994 deadline for EPA promulgation of onboard vapor recovery regulations ultimately may obviate the mandate for Moderate ozone nonattainment areas to implement Stage II programs, given the immediate and significant VOC reductions that will result from Stage II, as well as the air toxic benefits that will occur, Moderate ozone nonattainment areas should give serious consideration to implementing this cost-effective program in addition to onboard controls.

level and inspection frequency selected than on the control technology used. Emissions reductions can range from 56 percent to 92 percent, resulting in VOC emissions reductions of 360,000 to 600,000 tons per year nationwide and 160,000 to 260,000 tons per year in Moderate and above ozone nonattainment areas.

In general, Stage II systems have been shown to be 95 percent effective. California has a comprehensive certification process that all Stage II systems must pass before being installed in California. Most states are relying on this certification process and will accept Stage II systems only if they have been certified by California. A bootless nozzle system has recently been certified in California as 90 percent effective.

System efficiency tends to decrease with time because of equipment defects (torn nozzle boots, kinked hoses, etc.). Studies have shown that in-use efficiency increases with the frequency of enforcement inspections. For example, if no inspections are conducted, the system efficiency determined at the time of certification (95 percent) falls to 62 percent. If annual inspections are conducted, an in-use efficiency of 86 percent can be expected. If semi-annual inspections are conducted, an in-use efficiency of 92 percent can be expected.

The emissions reduction potential of a Stage II program is also affected by the number of facilities exempted. As illustrated below, overall program efficiency declines as exemption levels increase and inspection frequency decreases.

Program Efficiency Under Different Scenarios^a
(expressed as a percentage)

Exemption Level (gal/month)	Frequency of Inspections		
	None	Annual	Semi-Annual
No exemptions	62	86	92
2,000	61	84	90
10,000	60	84	89
10,000 + 50,000 (independents)	56	77	83

^aData derived from Figure 4-15 of EPA's technical guidance.

COST EFFECTIVENESS

The cost effectiveness of a Stage II program is also dependent on the exemption level and frequency of inspections. According to EPA's technical guidance document, cost effectiveness ranged from \$930/ton (\$1,020/Mg) for exempting all facilities that dispense less than 10,000 gallons per month and independents that dispense less than 50,000 gallons per month, to \$1,230/ton (\$1,350/Mg) for allowing no exemptions; these figures are based on an annual enforcement scenario.

FEDERAL RULEMAKING AND/OR GUIDANCE DOCUMENTS

The Clean Air Act Amendments of 1990 require the implementation of Stage II vapor recovery in Moderate, Serious, Severe and Extreme ozone nonattainment areas. Further, Section 184 of the statute calls upon EPA to complete a study by November 1993 identifying measures that can achieve emission reductions comparable to those obtained from Stage II. Areas within the Ozone Transport Region must adopt such measures or Stage II within one year of publication of the study.

Under the Act, EPA was to issue Stage II guidance by November 1991, an obligation that EPA fulfilled with the publication of the technical guidance document. Affected areas had until November 1992 to adopt Stage II rules. To assist the state and local agencies, EPA prepared a model Stage II rule.

Another method for controlling refueling vapors is onboard vapor recovery. Onboard control systems consist of valves, piping and a carbon canister "on board" the vehicle. Emissions produced during refueling are forced through the canister and adsorbed on the carbon. Vapors are then desorbed and burned in the engine during operation.

The Act allows Moderate ozone nonattainment areas to forego implementation of Stage II once regulations requiring onboard controls are promulgated.

However, it is significant to note that since onboard controls will be required only on new vehicles, it will take 10 to 15 years for onboard controls to achieve the same VOC reduction as Stage II.

In 1992, EPA announced its decision, based upon safety concerns, not to issue rules requiring onboard controls. On January 1993, the U.S. Court of Appeals set aside this decision and, pursuant to the requirements of the Clean Air Act, mandated the promulgation of regulations for onboard controls by January 1994. In June 1993, EPA announced its decision not to pursue the imposition of mandatory sanctions for failure to submit plans for Stage II in the approximately 20 Moderate ozone nonattainment areas required by the Act to implement Stage II until onboard control rules are promulgated.

STATE AND LOCAL CONTROL EFFORTS

In addition to California, other areas that have adopted Stage II include New York, New Jersey, Massachusetts, Pennsylvania, Florida, Missouri and Washington, DC. To improve enforcement and compliance, many states have established their own training programs and manuals for inspectors and affected facilities.

Further, to comply with the Stage II requirements of the Clean Air Act Amendments of 1990, many other state and local agencies are currently implementing Stage II.

REFERENCES

1. *Technical Guidance - Stage II Vapor Recovery Systems for Control of Vehicle Refueling Emissions at Gasoline Dispensing Facilities*. EPA/OAQPS (EPA-450/3-91-022a), November 1991.
2. Memoranda from G.T. Helms, Ozone/CO Branch, to Air Branch Chiefs Regions I-X: "Stage II Model Rule," August 21, 1992, and revisions, November 25, 1992.
3. Memorandum from John S. Seitz, OAQPS, to Regional Air Directors: "Impact of the Recent Onboard Decision on Stage II Requirements in Moderate Nonattainment Areas," June 23, 1993.

Table 1.....

Summary Table - Stage II Vapor Recovery

Affected Facilities	Any gasoline dispensing facility, public or private, that dispenses gasoline for the purpose of motor vehicle refueling.			
Number of Affected Facilities	Based on 1990 data, it is estimated that 420,000 facilities are potentially affected (assuming no exemptions), equally split between public and private.			
National Emissions Estimates	Uncontrolled nationwide vehicle refueling emissions represented 650,000 tons per year of VOCs in 1990. Of this, 280,000 tons occurred in Moderate and above ozone nonattainment areas.			
VOC Emissions Range Per Facility	Gasoline Throughput (Gallons/Month)	Small 6,000	Medium 35,000	Large 185,000
	VOC Emissions From Vehicle Refueling (Tons/Year)	0.4	2.3	12.3
Potential Emissions Reduction Per Facility	A VOC reduction of 86 percent per controlled facility can be achieved, assuming annual inspections and no exemptions. This reduction can be increased to 92 per-cent if semi-annual inspections are conducted.			
Cost Effectiveness	<p>Basis: Annual enforcement, moderately sized facility dispensing 65,000 gallons per month using multi-product dispensers.</p> <p>Capital Cost: \$24,120 Annual Cost: \$4,430 Cost Effectiveness: \$1,200/ton</p>			
STAPPA/ALAPCO Recommendation	Design rules to achieve a 95-percent level of efficiency; require California certification of equipment; limit exemptions to facilities with a throughput of less than 10,000 gallons per month; and require semi-annual inspections. In addition, Moderate ozone nonattainment areas should give serious consideration to implementation of a Stage II program. (Moderate nonattainment areas are not required by the Act to implement Stage II once regulations for onboard controls are promulgated. Pursuant to a court-ordered deadline, EPA is required to issue onboard rules by January 1994.)			

Surface Coating of Plastic Parts

DESCRIPTION OF SOURCE CATEGORY

This category includes industries that are engaged in applying coatings to plastic parts. Industrial segments covered by the category include the automotive/transportation industry and the business machinery/electronics industry, as well as miscellaneous other industries. The automotive/transportation segment includes plastic parts used in the interiors and exteriors of automobiles, trucks, lawn mowers and other vehicles. Within the business machines/electronics segment, coated parts include such things as plastic housings for electronic office equipment (e.g., computers and copy machines), medical equipment, televisions and stereos. The business machines/electronics segment not only requires decorative coatings, but also protective coatings to provide shielding from electromagnetic and radio frequency interference. The miscellaneous segment includes such products as toys, sporting goods, signs, doors, floors and window frames.

Facilities in the plastic parts surface coating industry vary widely in size, ranging from those having only one manual spray booth and no conveyor line or curing oven to others having multiple conveyorized lines, robotic spray booths and curing ovens. Coating steps may range from

single-step coating operations to three-step operations where a primer, colorcoat and clear coat are applied.

Plastic parts are often sprayed manually with a spray gun. After a part has been painted, it is conveyed to a flash-off area where the solvents evaporate or, if the coating requires heat for curing or drying, the part is moved to a curing oven. Oven temperatures may range from 150°F to 300°F.

The type of coating or substrate used, and the method in which it is applied, vary depending on the desired characteristics and end use of the product. Substrate coatings may include conventional solvent-based coatings, higher-solids coatings and waterborne coatings. The coatings contain volatile organic compounds (VOCs) that evaporate to the atmosphere during the coating and curing processes.

GEOGRAPHIC DISTRIBUTION OF SOURCES

Sources are distributed nationally. The U.S. Environmental Protection Agency (EPA) estimates that in nonattainment areas there are 125 facilities that coat automotive parts and 250 facilities that coat business machines and other miscellaneous products.

NATIONAL EMISSIONS ESTIMATES

VOC emissions in nonattainment areas are estimated at 16,500 tons/year for automotive coatings and 5,500 tons/year for business machines/miscellaneous coatings.

AVAILABLE CONTROL STRATEGIES

EPA's draft Control Techniques Guideline (CTG) discusses three general control strategies for regulating VOC emissions from the coating of plastic parts: low-VOC coatings, process modifications and add-on control equipment.

Low-VOC Coatings: The two main types of coatings that have low VOC contents are water-based and higher-solids coatings. In water-based coatings, some of the organic solvent is replaced with water. Higher-solids coatings increase the volume percent of solids, thereby reducing the amount of organic solvent in the coatings.

Other types of low-VOC coatings are available, but their usefulness in the coating of plastic parts is limited. Such coatings include powder coatings, ultra-violet (UV) or electronic beam (EB) cure coatings and vapor cure coatings. Powder coating involves the application of a finely ground dry powder, which adheres to a part's surface by means of an electrical attraction. After application, the coated parts are heated to melt the powder. In UV cure coatings, a chemical reaction occurs when substrate is exposed to ultraviolet light, causing the substance to cure and harden. In the electron-beam coating process, high energy electrons produced from an electron-beam radiation source are used to cure specially formulated coatings. Vapor cure coatings are urethane coatings that are cured primarily by exposure to an amine vapor.

Process Modifications: VOC emissions can also be controlled by modifying the coating application procedure. For example, switching to a spray gun that has a higher transfer efficiency reduces paint use and therefore reduces VOC emissions. There are five primary types of spray guns.

- Conventional air spray guns use compressed air to atomize the paint into a fine spray; these guns typically have a relatively poor transfer efficiency.
- Airless spray guns use a pump to force the coating through an atomizing nozzle; these guns typically have a better transfer efficiency than conventional air spray guns.
- Air-assisted, airless spray guns use lower fluid pressures than airless spray guns and lower air pressures than conventional air spray equipment.
- High-volume, low-pressure guns (HVLP) use large volumes of air under a lower pressure than the conventional spray system to atomize coatings.

STAPPA/ALAPCO Recommendation

► Coating of plastic parts is almost as diverse a category as miscellaneous metal parts coating and shares many of its attributes. One added constraint faced by plastic parts coating is that many plastic parts are heat sensitive and cannot be cured in an oven. Accordingly, consistent with the miscellaneous metal parts CTG, agencies should consider the following limits:

- 3.5 lb/gal for air-dried or forced warm air-dried application;
- 3.5 lb/gal for extreme performance application; and
- 3.0 lb/gal for all other applications (special limits are not needed for clear coats).

In addition, this category should be required to use high efficiency application techniques, such as HVLP spray, dip, roll coating, electrostatic or other approaches that achieve a minimum transfer efficiency of 65 percent.

- Electrostatic guns are used for electrostatic spray applications, in which the coating and grounded part are oppositely charged, causing the spray to be electrically attracted to the part. For electrostatic application, plastic parts must be made conductive by applying compatible polar solutions to the surface and/or placing the parts on a metal backing.

Another alternative is to eliminate the coating process by employing molded-in color techniques or shielding techniques. In the molded-in color process, a color pigment is added to the resin before or during the injection molding process. For shielding techniques, electromagnetic and radio frequency interference are reduced by using

conductive plastics instead of shielding-type coatings. According to EPA's CTG, this method is not currently in wide use. Another alternative is to insert metal plates inside the plastic housing, which eliminates the need for applying a shielding coating.

Add-on controls: Add-on controls include carbon adsorbers, thermal or catalytic incinerators and condensers.

- Carbon adsorbers use a bed of activated carbon to remove organic vapors from an incoming air stream.
- Thermal or catalytic incinerators oxidize or burn the vapor stream. Thermal incinerators operate by burning VOC vapors in a confined chamber at about 1400°F to 1600°F. Catalytic incinerators operate at temperatures of 500°F to 860°F and involve preheating the vapor stream and passing it over a catalyst site, on which oxidation occurs.
- Condensers (also known as refrigeration) capture VOC emissions by cooling the vapor stream to the dew point of the solvent and collecting the liquid droplets.

POTENTIAL NATIONAL EMISSIONS REDUCTION

Potential national emissions reductions depend on the level of control selected.

A control option based on the reformulation of solvent coatings would reduce VOC emissions from the automotive sector by 8,270 tons/year (50 percent) and from the business machines and miscellaneous sectors by 4,330 tons/year (79 percent). Waterborne coatings can reduce VOC emissions by 60 to 90 percent, higher solids coatings by 50 to 80 percent and powder coatings by 95 to 98 percent.

Changes in spraying methods can increase transfer efficiency and reduce coating use by as much as 25 percent. Other process modifications, such as using mold-in color techniques or using conductive plastics or metal inserts to reduce electromagnetic interference and radio frequency, eliminate the coating process entirely, resulting in 100-percent emissions reduction.

Carbon adsorption, thermal/catalytic oxidizers and condensers can provide emissions reductions of 95 percent and above.

COST EFFECTIVENESS

Table 1 summarizes the costs of controlling VOC emissions from the plastic parts surface coating industry. Control levels 1 and 2 refer to the use of low-VOC coatings. Control level 3 refers to the installation of a thermal incinerator. As the table shows, the use of low-VOC coatings has a cost-effectiveness range of \$632 to \$650 per ton of VOC removed for automotive coatings and \$470 to \$473 per ton of VOCs removed for business machine/miscellaneous coatings. Thermal incineration has a cost effectiveness range of \$6,100 to \$10,500 per ton of VOCs removed.

FEDERAL RULEMAKING AND/OR GUIDANCE DOCUMENTS

EPA is preparing a CTG for the surface coating of plastic parts and anticipates submitting the draft guideline to the Office of Management and Budget (OMB) in the summer of 1993. Following approval by OMB, the guideline is expected to be published in final form later this year.

❖ *For more information on the CTG, contact Dave Salmon, U.S. Environmental Protection Agency, Emission Standards Division (MD-13), Research Triangle Park, NC 27711 (telephone: 919/541-0859).*

STATE AND LOCAL CONTROL EFFORTS

Several state and local agencies, including Texas, New York, Missouri, Michigan, Maryland and California, have adopted regulations to control VOCs from facilities that apply surface coatings to plastic parts. State and local limits on the VOC content of coatings range from 2.3 pounds per gallon for general one-component coatings to 6.7 pounds per gallon for vacuum metalizing, optical and electric dissipating coatings. In addition, Maryland and New York have adopted efficiency requirements in lieu of limits on VOC content in cases where control devices are used.

The South Coast Air Quality Management District's (SCAQMD's) Rule 1145 – Plastic, Rubber and Glass Coatings-limits the VOC content of the materials used and requires the use of high transfer efficiency applicators or a control device. The Bay Area Air Quality Management District (BAAQMD) allows add-on controls if they achieve emissions reductions equivalent to those occurring from compliance coatings. Michigan restricts the use of conventional air-atomized spray.

REFERENCES

1. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. October 7, 1991. *Surface Coating of Plastic Parts: Control Techniques Guideline*. Draft.
2. Lake Michigan Air Directors Consortium. April 16, 1993. *Lake Michigan Ozone Control Program Evaluation of Possible Control Measures. Control of Surface Coating of Plastic Parts (VOC)*. Draft.
3. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. June 1978. *Control of Volatile Organic Emissions from Existing Stationary Sources - Volume VI: Surface Coating of Miscellaneous Metal Parts and Products*. EPA-450/2-78-015.

Table 1.....

Summary of Costs of Controlling VOC Emissions from Plastic Parts Coating Operations

Control Option	National Emission Reduction (tons/yr)	National Costs (10 ⁶ \$/yr)	Cost Effectiveness ^a (\$/ton)	Incremental Cost Effectiveness ^b (\$/ton)
Automotive/Transportation				
1	5,720	3.61	632	—
2	8,270	5.37	650	690
3	15,600	164.00	10,500	21,600
Business Machines				
1	2,830	1.33	470	—
2	4,330	2.05	473	481
3	4,850	29.60	6,100	53,400

^aCost effectiveness of Options 1 and 2 (reformulation) is calculated using national coating usage data. Cost effectiveness of Option 3 (add-on controls) is calculated using model plants. All three options are calculated from baseline.

^bCalculated from next less stringent option.

Table 2
Summary Table - Surface Coating of Plastic Parts

Affected Facilities	Two primary industry segments: 1) business machinery and 2) automotive/transportation.		
Number of Affected Facilities	125 facilities manufacturing automotive/transportation parts and 250 facilities manufacturing business machines.		
National Emissions Estimates	16,500 tons/year of VOCs from automotive/transportation coatings; 5,500 tons/year from business machine coating.		
VOC Emissions Range Per Facility	Table 5-2 of EPA's draft CTG estimates the baseline VOC emissions on a model plant basis for each industry segment. The baseline model plant emissions are presented below.		
	Model Plant	Consumption (gal coating/yr)	Emissions (tons VOC/yr)
	A ^a	5,127	12.3
	A - 1 ^b	12,000	36.6
	A - 2 ^b	12,000	28.4
	A - 3 ^b	12,000	27.8
	B ^a	41,000	98.5
	B - 1 ^b	27,250	82.8
	B - 2 ^b	27,250	64.4
	B - 3 ^b	27,250	63.0
	C ^a	102,507	246
	C - 1 ^b	97,540	297.5
	C - 2 ^b	97,540	230.4
	C - 3 ^b	97,540	225.6
	D - 1 ^b	300,000	915
	D - 2 ^b	300,000	709
	D - 3 ^b	300,000	694
100 TPY Source Size	A facility in the business machines or miscellaneous sector using more than 42,000 gallons of coating per year would be classified as a 100-tpy source. In the automotive/transportation industry, a facility applying more than 33,000 gal/year of interior paints would be classified as a 100-tpy source. A facility applying more than 42,000 gal/year of flexible and non-flexible exterior paints would be classified as a 100-tpy source.		
Potential Emissions Reduction Per Facility	Listed below are estimated VOC reductions, by model plant, expressed as percentages using the control levels discussed earlier.		
	Model Plant	Control Level 1 (%)	Control Level 2 (%)
	A ^a	50	78
	A - 1 ^b	70	86
	A - 2 ^b	21	34
	A - 3 ^b	21	37

-continued

Table 2 —continued

Potential Emissions Reduction Per Facility—continued	Model Plant	Control Level 1 (%)	Control Level 2 (%)	Control Level 3 (%)
	B ^a	50	78	88
	B - 1 ^b	70	86	96
	B - 2 ^b	21	34	88
	B - 3 ^b	21	37	88
	C ^a	50	78	88
	C - 1 ^b	70	86	96
	C - 2 ^b	21	34	88
	C - 3 ^b	21	37	88
	D - 1 ^b	70	86	98
	D - 2 ^b	21	34	98
	D - 3 ^b	21	37	98
Cost Effectiveness	For low-VOC coatings, cost effectiveness ranges from \$632 to \$650/ton of VOC removed for automotive coatings and from \$470 to \$473/ton for business machine and miscellaneous coatings. The cost effectiveness of thermal incineration ranges from \$6,100 to \$10,500/ton of VOC removed. (See Table 1.)			
Federal Rulemaking and/or Guidance Documents	EPA is preparing a draft CTG for the surface coating of plastic parts, which it anticipates submitting to OMB in the summer of 1993. Following approval by OMB, the CTG is expected to be published later this year.			
State and Local Control Efforts	Several state and local agencies, including Texas, New York, Missouri, Michigan, Maryland, California, SCAQMD and BAAQMD, have adopted regulations to control VOCs from facilities that coat plastic parts. All agencies have adopted a limit on the VOC content of the coatings used ranging from 2.3 pounds per gallon for general one-component coatings to 6.7 pounds per gallon for vacuum metalizing, optical, and electric dissipating coatings. In addition, Maryland and New York have adopted efficiency requirements in lieu of limits on VOC content if control devices are used. SCAQMD's Rule 1145 limits the VOC content of the materials used and requires the use of high transfer efficiency applicators or a control device. BAAQMD allows add-on controls if they achieve equivalent emissions reduction. Michigan has restricted the use of conventional air-atomized spray.			
STAPPA/ALAPCO Recommendation	Consider requiring the following limits: 3.5 lb/gal for air-dried or forced warm air-dried application, 3.5 lb/gal for extreme performance application and 3.0 lb/gal for all other applications (special limits are not needed for clear coats); use HVLP spray or other techniques achieving a minimum transfer efficiency of 65 percent.			

^aModel plant for business machines and miscellaneous industry.

^bModel plant for automotive/transportation industry:

MP A-1, B-1, C-1 and D-1 apply interior paints;

MP A-2, B-2, C-2 and D-2 apply flexible, exterior paints; and

MP A-3, B-3, C-3 and D-3 apply non-flexible exterior paints.

Synthetic Organic Chemical Manufacturing Industry Reactor and Distillation Processes

DESCRIPTION OF SOURCE CATEGORY

The synthetic organic chemical manufacturing industry (SOCMI) is a large and diverse industry producing organic products for consumers and industry using a variety of unit operations, including reaction and distillation processes.

A reaction process is defined as the chemical transformation of raw materials into products. The products of the reaction step are often in a dilute or unrefined state and additional processing is required to purify the products.

Distillation separates organic compounds by taking advantage of boiling points and vapor pressure differences between compounds.

The overall synthetic organic chemical industry can be described as a series of production stages. The first stage consists of the collection and separation of naturally occurring organic materials into their usable chemical components. Crude oil refineries, natural gas plants and coal tar distillation plants are examples of first stage production facilities. These types of plants typically have large production volumes and low unit costs. Second stage facilities use the industrial products from the first stage plants as raw

materials and are characterized by medium-sized plants that make a variety of final products in medium-sized volumes. The third stage consists of facilities that produce specialty chemicals and have a low volume of production and high unit manufacturing costs.

The chemical industry produces 128 million megagrams (Mg) (273 billion pounds) per year; this production includes over 7,000 different chemicals. However, only a relatively small number of chemicals dominates organic chemical output. Because of this, only 719 chemical products comprise the SOCMI category.

GEOGRAPHIC DISTRIBUTION OF SOURCES

Stage one plants are usually located near the source of their raw materials, while stage two and stage three plants are usually located closer to their markets. Stage one plants therefore tend to be near natural gas, oil and coal fields and large ports of call, while stage two and stage three plants usually are concentrated near metropolitan areas.

NATIONAL EMISSIONS ESTIMATES

Nationwide volatile organic compound (VOC) emissions from SOCMIs reactors and distillation processes are estimated at 4,800 Mg per year.

AVAILABLE CONTROL STRATEGIES

There are two primary techniques for controlling VOC emissions from SOCMIs reactors and distillation process: oxidation techniques and recovery techniques.

Oxidation Techniques: These techniques include flares, thermal incinerators, catalytic incinerators and industrial boilers/process heaters.

- Flares use an open oxidation (combustion) process in which ambient air is mixed with an emissions stream (fuel) at the flare tip. Flares can be ground-mounted or elevated, the latter being the most common type used in the synthetic organic chemical industry. Often an inert purge gas (nitrogen or carbon dioxide) is added to the vent exhaust to prevent flashback. High-velocity steam is frequently added to vent gases through injection nozzles to increase VOC/air turbulence to improve combustion. The use of high-velocity steam promotes smokeless flare operation, but increases cost and noise.
- Thermal incineration involves heating VOC contaminants to their autoignition temperature in the presence of sufficient oxygen to affect complete combustion. A thermal incinerator is typically composed of a refractory-lined chamber with gas burners at one end. The chamber is sized to permit a residence time of 0.3 to 1.0 second at the maximum gas flow rate. Heat is commonly recovered by using flue gases to preheat combustion air and/or vent gases; however, if a heat recovery process is used, insurance regulations require that VOC concentrations be kept below 25 percent of the lower explosive limit (LEL) to prevent explosion hazards. Test results demonstrate that thermal oxidizers can achieve 98 percent VOC destruction efficiency for most VOCs at a combustion chamber temperature ranging from 1200°C to 1600°C and a residence time of 0.5 to 1.5 seconds.
- Catalytic incinerators introduce a catalyst that can dramatically increase the chemical rate of reaction of VOCs with oxygen, thus reducing the minimum combustion temperature needed to destroy VOCs. The catalyst itself is not altered during the reaction. Typical operating temperatures for catalytic incin-

erators range from 260°C to 427°C, resulting in a significant fuel savings over thermal incinerators. In addition, catalytic incinerators can process dilute VOC streams in which the concentration of VOCs is well below the LEL, which can be an advantage in some processes. Disadvantages of catalytic units include higher installed costs and the possibility of catalyst poisoning by sulfur, metals and phosphorus. Overall destruction removal efficiency (DRE) is dependent on space velocity, operating temperature, oxygen concentration and VOC composition and concentration. A catalytic unit can typically achieve 95 percent VOC DRE.

- Industrial boilers or process heaters destroy VOCs by combining reactor and/or distillation vent streams with the inlet fuel. One example is a high-intensity or vortex burner with process vent streams having low heating values. Operating profiles for boilers and heaters vary depending upon the application, but usually entail temperatures over 1,200°C and residence times between 0.25 to 0.83 seconds. An EPA-sponsored test indicated that 99 percent of polychlorinated biphenyl (PCBs) could be destroyed in an oil-fired industrial boiler heated to between 1,361°C and 1,520°C with a residence time of 2 to 6 seconds.

Recovery Techniques: Such techniques include adsorption and absorption.

- Adsorption is an operation involving the transfer of VOCs from the gas phase to a solid. The most commonly used adsorption system involves the use of activated carbon, which is effective in capturing most VOCs by a physical adsorption mechanism. The activated carbon can be regenerated by steam or nitrogen stripping or by high vacuum regeneration. The minimum equipment required for an adsorption process are two adsorption beds and a regeneration facility. Adsorption can achieve a removal efficiency of up to 95 percent for selected chemicals.
- Absorption systems are usually divided into two types: direct contact and noncontact condensers. Direct contact condensers spray a cooled liquid directly into the emission stream. This contact is made either in a packed or unpacked vessel or tower. Liquid separators are usually required to separate the cooling media from the condensate. An exception is when the cooling media used is the same material as the condensate. Noncontact condensers incorporate a physical barrier between the

cooling media and the gases to be condensed. The best known example of this type of condenser is a shell and tube heat exchanger. Hot gases pass through the inside of the tubes, are cooled and then condense. The cooling medium is circulated on the shell side and never makes direct contact with the condensate. The cooling medium could be anything from ambient temperature water to highly refrigerated brine solution.

POTENTIAL NATIONAL EMISSIONS REDUCTION

The VOC reduction potential from installation of Reasonably Available Control Technology (RACT) on SOCMIs reactors and distillation processes is estimated at 4,700 Mg per year.

The U.S. Environmental Protection Agency's (EPA's) draft Control Techniques Guideline (CTG) developed emission scenarios for several model plant vents to evaluate the effect of RACT on SOCMIs reactors and distillation processes, using cost effectiveness as the basis. This information is presented in Table 1, which presents eight RACT implementation options, each driven by a maximum cost-effectiveness value. For example, if a SOCMIs facility was required by an agency to comply with Option 5, the facility would need to calculate a cost-effectiveness value to control each vent stream. Streams having a cost effectiveness below \$5,000/Mg would be required to implement RACT.

COST EFFECTIVENESS

EPA's draft CTG only addressed oxidation techniques when developing cost-effectiveness estimates. According to estimates presented in the CTG, the cost effectiveness of controlling VOC emissions from SOCMIs processes ranges from \$266 to \$23,546 per Mg (\$241 to \$21,360/ton) of VOCs removed. The lowest cost effectiveness is for sources classified as high-flow and high-heat-value and is based on a non-halogenated emission stream. The highest cost effectiveness is for low-flow and low-heat-value sources processing halogenated hydrocarbons. Complete cost-effectiveness data are shown in Table 2.

FEDERAL RULEMAKING AND/OR GUIDANCE DOCUMENTS

EPA published a draft CTG for SOCMIs reactors and distillation processes in January 1991. The CTG describes controls, such as thermal incinerators and flares, that are applicable to all SOCMIs reactor and distillation processes. These techniques generally can achieve the highest emis-

STAPPA/ALAPCO Recommendation

► All SOCMIs sources can achieve a 98-percent reduction in emissions. At issue is how low in flow or heat value the stream must be before the waste gas stream is exempted from control.

EPA has developed a draft CTG with exemptions for processes based on a TRE index. The CTG exempts sources with a TRE higher than 1.0. This corresponds to a maximum cost of control of approximately \$2,300/ton. Use of the EPA rule with a higher TRE (e.g., 2.0) would better reflect costs being incurred by other sources in nonattainment areas; typical costs will be lower than the TRE cost of control.

sions reduction among demonstrated VOC control technologies. Both techniques can achieve a 98-percent reduction (based on weight) in VOC emissions from process vents if the control devices are properly designed, installed, operated and maintained.

The control level representing RACT does not specify thermal incinerators or flares. While these techniques are widely used and are readily available, any control device capable of achieving the 98-percent removal/destruction efficiency may be used.

The total resource effectiveness (TRE) index was chosen as the applicability measure of RACT for the CTG. The TRE index is a decision tool used to determine if the annual cost of controlling a given vent gas stream is acceptable, considering the emission reductions achieved. The TRE index equation is a measure of the cost per unit of VOC emissions reduction and is normalized so that the decision point has a defined value of 1.0. The variables in the TRE index equation are the stream characteristics, such as flow rate, heat value, VOC emission rate and the maximum cost effectiveness selected. If the TRE index for a specific stream is less than or equal to 1.0, the vent emissions should be controlled by a combustion device. However, as an alternative, some sources may instead choose to reduce the VOC concentration of the stream. As a result, the TRE would increase and a control device would not be

required.

The draft CTG has been reviewed and approved by the Office of Management and Budget (OMB); final publication is expected by the late summer or early fall of 1993.

In addition, EPA has also published CTGs for polyethylene, polypropylene and polystyrene manufacturing, as well as for SOCMi air oxidation processes.

❖ *For further information on the SOCMi CTG, contact Les Evans, U.S. Environmental Protection Agency, Emission Standards Division (MD-13), Research Triangle Park, NC 27711 (telephone: 919/541-5410).*

STATE AND LOCAL CONTROL EFFORTS

Michigan's Rule 628, which became effective in April 1989, addresses VOC emissions due to valve leakage from existing process equipment used in manufacturing synthetic organic chemicals and polymers.

Illinois has CTG-based rules that address RACT for SOCMi air oxidation processes and polyethylene, polypropylene and polystyrene manufacturing.

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Table 1.....
Impacts of Reasonably Available Control Technology on the Halogenated and Nonhalogenated Vent Streams^a

Option	Maximum Cost Effectiveness (\$/Mg)	Stream Controlled ^b (%)	National VOC Emission Reduction ^c (Mg/yr)	National Secondary Emissions of NO _x (Max) ^d (Mg/yr)	National Secondary Emissions of CO ^e (Mg/yr)	National Cost Impacts ^{c,f} (\$ x 10 ³ /yr)	Average Cost Effectiveness ^f (\$ x 10 ³ /Mg)	Incremental Cost Effectiveness ^f (\$ x 10 ³ /Mg)	Average Emission Reduction Per Vent in Increment Controlled ^g (Mg/yr)	Average Cost Per Vent in Increment Controlled ^h (\$/yr)
1	All	100	4,800	153 (48)	69	6 - 13	12 - 2.6	> 31 - 64	1.5	93,000
2	20,000	63	4,700	100 (48)	40	3.4 - 7.3	0.7 - 1.5	> 5.9 - 15	5.2	80,000
3	10,000	41	4,500	84 (8)	38	2.3 - 4.5	0.5 - 1	> 4.3 - 9	9.5	85,000
4	8,000	36	4,450	83 (8)	38	2.0 - 3.9	0.45 - 0.9	> 1.7 - 6.9	10.2	70,000
5	5,000	23	4,300	80 (2)	36	1.7 - 2.5	0.4 - 0.6	> 0.5 - 3.4	17.5	59,000
6	3,000	16	4,100	79	361	.6 - 1.9	0.39 - 0.46	> 1.4 - 2.6	21.3	55,000
7	2,500	15	4,000	79	36	1.5 - 1.8	0.38 - 0.44	> 1.9 - 2.3	26.6	62,000
8	2,000	12	3,900	74	34	1.3 - 1.5	0.34 - 0.39	> 0.34 - 0.39	206	80,000

^aIt is assumed that 95-percent control on all streams >5 lbs/hr reflects current level of control due to state and local regulations; based on first quarter 1990 dollars.

^bRepresents the number of vent streams controlled at a particular cutoff level divided by the total number of model vent streams in the data base.

^cIt is assumed that 60 percent of the facilities are in nonattainment areas.

^dNO_x emission factors used:

Incinerators: 200 parts per million (ppm) in exhaust for streams containing nitrogen compounds and 21.5 ppm NO_x on all other streams (based on test data).

Flares: 0.05 lb/million British thermal units (based on EPA 600/2-83-052).

^eCO emissions based on 20 lb/million standard cubic feet (AP-42).

^fImpacts shown for two cases: 1) utilization of existing controls for streams below 23 standard cubic feet per minute and larger streams costed with a dedicated device; 2) all streams costed with dedicated devices.

^gRepresents the additional emission reduction divided by the additional number of vent streams controlled at a particular cutoff level relative to the next least stringent cutoff level.

^hRepresents the additional cost divided by the additional number of vent streams controlled at a particular cutoff level relative to the next least stringent cutoff level.

Table 2
Cost Effectiveness Data

Source Type (flow/heat value) ^a	Halogenated Compound (Yes/No)	Control Device	Capital Cost (\$10 ³)	Total Annual Cost (\$10 ³ /yr)	Cost Effectiveness (\$/Mg VOC)
Reactor:					
LF/HH	Yes	Incinerator w/scrubber	114	115	3,529
LF/LH	Yes	Incinerator w/scrubber	116	116	8,306
HF/HH	No	Thermal incinerator	292	239	303
HF/LH	No	Thermal incinerator	110	72	13,778
Average	No	Flare	29	53	6,638
Distillation:					
LF/HH	No	Thermal incinerator	114	75	2,387
LF/LH	Yes	Incinerator w/scrubber	115	119	23,546
HF/HH	Yes	Incinerator w/scrubber	243	158	266
HF/LH	No	Thermal incinerator	101	90	375
Average	No	Flare	30	54	696

^aLF = Low Gas Flow
HF = High Gas Flow
HH = High Heat Value
LH = Low Heat Value

Table 3
Summary Table – SOCMI Reactor and Distillation Processes

Affected Facilities	All SOCMI reactor and distillation process vents.				
Number of Affected Facilities	Approximately 23 facilities.				
National Emissions Estimates	4,800 Mg/yr of VOCs.				
VOC Emissions Range Per Facility	Model Vents Uncontrolled Mg/yr	LF/LH 5.16	LF/HH 8.14	HF/LH 24.41	HF/HH ^a 605.3
Potential Emissions Reduction Per Facility	Model Vents Uncontrolled Mg/yr	0.10	0.16	0.49	12.11
Nationwide VOC reduction estimated at between 3,900 Mg and 4,800 Mg/yr.					
Cost Effectiveness	Capital Cost (per vent): \$29,000 to \$292,000 Annual Cost (per vent): \$53,000 to \$239,000 Cost Effectiveness: \$ 2,000 to \$ 20,000 per Mg of VOC controlled				
Federal Rulemaking and/or Guidance Documents	Draft CTG, which has been approved by OMB and expected to be published in final form in the late summer or early fall of 1993, recommends 98-percent reduction in VOC emissions from all vents that have TREs less than 1.0.				
State and Local Control Efforts	Michigan's Rule 628 controls emissions from valve leakage. Illinois has CTG-based rules to address RACT for SOCMI air oxidation processes and polyethylene, polypropylene and polystyrene manufacturing.				
STAPPA/ALAPCO Recommendation	All SOCMI sources can achieve 98-percent reduction in emissions. At issue is how low in flow or heat value the stream must be before the waste gas stream is exempted from control. EPA has developed a draft CTG with exemptions for processes based on a TRE index that exempts sources with a TRE higher than 1.0. This corresponds to a maximum cost of control of approximately \$2,300/ton. Use of the EPA rule with a higher TRE (e.g., 2.0) would better reflect costs being incurred by other sources in nonattainment areas; typical costs will be lower than the TRE cost of control.				

^aLF = Low Flow Rate
HF = High Flow Rate
LH = Low Heat Value
HH = High Heat Value

Textile Finishing

DESCRIPTION OF SOURCE CATEGORY

Textile finishing is categorized under Standard Industrial Classification Code 226 and applies to facilities engaged in finishing operations (e.g., bleaching; dyeing; printing; and preshrinking for cotton, synthetic, and silk broadwoven fabrics). According to EPA, 84 percent of the volatile organic compound (VOC) emissions that occur in textile finishing operations are generated by the drying and heat curing of printed fabrics. Textile printing is the result of colored designs or patterns on textile substrates using roller and screen printing methods. Most VOC emissions from fabric printing result from the use of print pastes or inks containing organic solvents (e.g., methyl ethyl ketone, methyl isobutyl ketone, toluene and varsol). Vat dyeing and sizing are also sources of VOC emissions.

GEOGRAPHIC DISTRIBUTION OF SOURCES

In 1987, North Carolina, South Carolina and Georgia were the leading states for employment in the textile finishing industry.

NATIONAL EMISSIONS ESTIMATES

Due to the complexity and variability of the printing, dyeing, finishing and other operations included in this source category, there are no national VOC emission estimates available. Most existing information regarding VOC emissions is site- and operation-specific.

AVAILABLE CONTROL STRATEGIES

Reducing VOC emissions in the textile finishing industry can be accomplished through product substitution (e.g., low-VOC print paste) or the use of add-on control devices.

Product Substitution: This approach involves replacing print paste having a high organic solvent content with a lower-VOC or water-based print paste. The organic solvent concentration in print paste can be as high as 60 percent. However, in some applications, using a low-VOC or water-based ink may not be suitable.

Add-on Controls: Aerosol formation and particulate capture represent one type of add-on control that can be used to control VOC emissions from textile finishing. In addition, there are add-on devices for gases that can either destroy or recover the VOCs in the exhaust stream from the hot-air dryers used to cure heatset inks. These devices typ-

ically include thermal incinerators, catalytic incinerators and carbon adsorbers. Thermal and catalytic incinerators destroy the VOCs in the emission stream, while the carbon adsorbers recover the solvent to be reused on site.

- Aerosol formation and particulate capture involve the cooling of stack gases to approximately 10°F so that the vapor condenses to form liquid droplets or particles. The droplets or particles can be removed using conventional particulate control devices such as demisters/cyclones, scrubbers and electrostatic precipitators.
- Thermal incinerators burn or oxidize VOCs in the emission stream; the VOCs are converted into carbon dioxide and water. Such incinerators typically operate at temperatures of 1600°F, requiring a residence time of 0.75 seconds. Dilute vapor streams may require the use of supplemental fuel (e.g., natural gas) to aid in combustion.
- Catalytic incinerators also burn or oxidize VOCs in the emissions stream; however, they use a catalyst (e.g., metal oxides or precious metals that are supported on ceramic or metallic substrates) to aid in combustion. In the presence of the catalyst, VOCs can be destroyed at temperatures ranging from 660°F to 930°F. The lower operating temperature reduces the need for supplemental fuel.
- Carbon adsorbers usually use two or more activated carbon beds to adsorb VOCs from the vapor stream. The carbon beds are operated in parallel so that when the capacity of one bed is reached, the vapor stream can be routed to the second bed while the first bed is reactivated. Reactivation, or regeneration, is accomplished by heating the bed with steam or hot air to drive off the adsorbed organics.

POTENTIAL NATIONAL EMISSIONS REDUCTION

Little information exists quantifying the reduction potential of using low-organic solvent or water-based print paste in the textile finishing industry. However, the U.S. Environmental Protection Agency (EPA) has published VOC emission factors indicating zero emissions for some textile fabric printing operations that use a water-based print paste. This implies that, in cases where water-based print pastes are applicable, a 100-percent VOC emissions reduction can be achieved.

EPA has also estimated potential annual VOC emissions reductions from implementation of New Source Performance Standards (NSPS) as follows: 21,300–202,000 tons for printing, 39,400–129,000 tons for dyeing and

STAPPA/ALAPCO Recommendation

- State and local agencies should consider requiring add-on controls for textile finishing operations that achieve a control device efficiency of at least 95 percent. Capture efficiency should be based upon best engineering practices. Agencies may consider exempting low-solvent inks (those containing 12 percent or less solvent by weight) from control requirements.

21,000–78,900 tons for final textile finishing operations.

In 1981, as part of its efforts to develop an NSPS for the fabric printing industry (this effort was subsequently postponed indefinitely), EPA published four regulatory alternatives to control VOC emissions. Regulatory Alternative I represented uncontrolled baseline emissions (i.e., a “do-nothing” alternative). Regulatory Alternative II required facilities using high-organic solvent content print paste (50 to 60 percent by weight) to convert to print pastes containing a weighted average of 24 percent organic solvent (by weight). It was estimated that by implementing this alternative, national VOC emissions due to fabric printing could be reduced by 40 percent, thus, eliminating 5,000 tons of VOCs per year. Regulatory Alternative III limited the solvent content of print paste to 12 percent by weight, which affected facilities using medium- or high-organic solvent contents print paste (23 to 60 percent by weight). This alternative was estimated to reduce national VOC emissions by almost 7,500 tons per year. Regulatory Alternative IV called for adding thermal incinerators to control drying process emissions from any affected facility using print pastes containing organic solvents. This alternative was estimated to reduce national VOC emissions by almost 10,000 tons/year.

According to EPA, condensation, thermal and catalytic incineration and carbon adsorption are capable of removing 95 percent or more of the hydrocarbons in the concentration range of 200 to 8,000 parts per million volume (ppmv) from textile plant stack gases.

COST EFFECTIVENESS

EPA has developed preliminary capital and annual costs for applying add-on controls at textile finishing plants where the stack gas hydrocarbon emission concentrations were 200, 3,000, and 8,000 ppmv. The costs developed assumed a 96-percent overall VOC control efficiency in the VOC stack concentration. Where there was a net annual revenue or savings, an estimated system "payback" was calculated. However, since the cost information was measured in 1980, much of it is outdated.

The agency has also prepared cost information in developing the NSPS for textile fabric printing. The costs associated with the four Regulatory Alternatives were developed on a model plant basis and they are summarized in Table 1. Model plant 1 is a rotary screen operation using print paste with a VOC content of 37 percent (by weight), emitting 263 tons of VOC annually. Model plant 2 is a flat screen operation using print paste with a VOC content of 24 percent (by weight), emitting 31 tons of VOC per ton. Model plant 3 is a roller screen operation using print paste with a VOC content of 59 percent (by weight), emitting 296 tons VOC per year.

FEDERAL RULEMAKING AND/OR GUIDANCE DOCUMENTS

Currently, EPA has no plans to issue rules or guidance regulating the textile finishing industry.

STATE AND LOCAL CONTROL EFFORTS

North Carolina is gathering background information concerning air toxics from its textile industry. The objectives of the study are to analyze toxic air emissions from the North Carolina textile industry in order to determine their effect on air quality; study existing emission factors for the industry to determine if they are adequate; and develop emission factors from literature searches or emission testing and analysis, if necessary.

The South Coast Air Quality Management District (SCAQMD) regulates VOC emissions from web-fed fabric coating operations under Rule 1128, Paper, Fabric, and Film Coatings Operations. This rule limits the VOC content of materials used and requires high transfer efficiency applicators. Compliance may also be achieved by the use of an emissions control device or an Alternative Emission Control Plan (AECp). SCAQMD Rules 1130, Graphic Arts and 1130.1, Screen Printing Operations, regulate the VOC emissions from individually-cut fabric printing or coating operations. These rules limit the VOC content of materials used or require use of a control device or an AECp. In

addition, Rule 1130.1 prohibits soliciting, selling or requiring VOC-containing material to be used if it does not meet the specified limits and requirements. To achieve further emission reductions, SCAQMD's 1991 Air Quality Management Plan Tier I control measure P-A-3, Further Emission Reductions from Paper, Fabric, and Film Coating, proposed to include nonheated drying and curing processes under Rule 1128. This was accomplished when Rule 1128 was amended on February 7, 1992.

In Illinois, the use of print paste and inks containing organic solvents is regulated under graphic arts. Reasonably Available Control Technology is the use of pastes or inks with less than 25 percent volatile organic material by volume of the volatile organic content.

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TEXTILE FINISHING

Table 1

Estimated Capital Costs, Annual Costs and Cost Effectiveness of Proposed Regulatory Alternatives for NSPS for the Textile Fabric Printing Industry ^a

Option	Model Plant 1			Model Plant 2			Model Plant 3		
	Capital (\$1,000)	Annual (\$1,000)	Cost Effectiveness ^b (\$/ton)	Capital (\$1,000)	Annual (\$1,000)	Cost Effectiveness ^b (\$/ton)	Capital (\$1,000)	Annual (\$1,000)	Cost Effectiveness (\$/ton)
I	BASELINE "DO NOTHING" ALTERNATIVE			BASELINE "DO NOTHING" ALTERNATIVE			BASELINE "DO NOTHING" ALTERNATIVE		
II	500	1,059	(300)	420	455	—	650	1,045	290
III	500	1,027	(310)	420	451	(240)	230	1,023	300
IV	981	1,238	(590)	835	576	4,060	687	1,245	520

^a See Reference 5.

^b Figures in parenthesis represent a credit or savings.

Table 2

Summary Table — Textile Finishing

Affected Facilities	Facilities engaged in finishing operations, such as bleaching, dyeing, printing and cotton, synthetic and silk pre-shrinking.
Cost Effectiveness	Based upon cost information from 1980, cost effectiveness ranges from a credit of \$590 per ton to a cost of \$4,060 per ton of VOC removed. (For more information, see Table 1 and References 2 and 5.)
Federal Rulemaking and/or Guidance Documents	An NSPS for the fabric printing industry was postponed indefinitely by EPA in 1981, due to the adverse economic impact projected for the Regulatory Alternatives evaluated for the standard. (For more information, see Reference 5.)
State and Local Control Efforts	North Carolina is gathering background information concerning air toxics from its textile industry. SCAQMD regulates emissions under District Rules 1128 and 1130. Illinois regulates the use of pastes and inks under graphic arts.
STAPPA/ALAPCO Recommendation	Require add-on controls achieving a control device efficiency of at least 95 percent; base capture efficiency on best engineering practices; consider exempting low-solvent inks.

Treatment, Storage and Disposal Facilities

DESCRIPTION OF SOURCE CATEGORY

Treatment, storage and disposal facilities (TSDFs) manage hazardous wastes containing volatile organic compounds (VOCs) and hazardous air pollutants (HAPs). In addition to stationary sites (e.g., facilities employing cement kilns to destroy hazardous wastes), TSDFs include mobile units, such as those used for site-specific cleanups. Approximately 96 percent of the hazardous wastes managed at TSDFs are generated and managed on the same site. The types of wastes handled and the management processes used vary widely from one facility to another. Broad categories of waste include dilute wastewaters (representing more than 90 percent by weight of the total waste managed), organic and inorganic sludges and organic and inorganic solids.

Waste management processes include storage and treatment in tanks, surface impoundment and waste piling; handling or storage in containers, such as drums, tank trucks, tank cars and dumpsters; and disposal of waste by incineration, land treatment, underground injection or placement in landfills. In addition, hazardous waste may be managed in miscellaneous units not included in any of

the above processes. Hazardous waste may also be handled in research, development and demonstration units.

GEOGRAPHIC DISTRIBUTION OF SOURCES

A U.S. Environmental Protection Agency (EPA) survey found that there were 2,331 facilities located throughout the United States in 1986. The survey identified more than 150 different industries that generate hazardous waste, with most involved in manufacturing. Approximately 500 of the TSDFs identified are commercial facilities that manage hazardous waste generated by others.

NATIONAL EMISSIONS ESTIMATES

Nationwide organic emissions from TSDFs are estimated at around 1.8 million megagrams per year (Mg/yr) (2.0 million tons/year).

AVAILABLE CONTROL STRATEGIES

There are several strategies for reducing organic emissions from TSDFs, including containment and control and pre-treatment.

Containment and Control: Containment and control involves the application of add-on devices to control emissions from individual tanks, surface impoundments and containers. Organic vapors can be suppressed by applying a cover that directly contacts the waste medium, thereby creating a physical barrier that inhibits the volatilization of organics.

Another method for containing VOCs is to form a closed vapor space above the waste surface by erecting an enclosure over the entire waste management unit or, for some types of open-top units, installing a cover. This containment method can be used in combination with a closed vent system and a control device (e.g., a carbon adsorber, a vapor incinerator or a condenser) to capture and treat organic vapors released from the waste.

Pretreatment: Pretreatment removes or destroys organics in the hazardous waste prior to its placement in tanks, surface impoundments or containers, thus reducing organic emissions from all subsequent waste management processes without the need for add-on emissions controls. When waste is incinerated, there are no additional waste handling steps (other than the disposal of ash and other noncombustible residuals) and thus there are no subsequent waste management units that are sources of organic emissions. However, pretreatment steps should be evaluated carefully to ensure that the total hazardous waste treatment emissions are less than the emissions without pretreatment.

POTENTIAL NATIONAL EMISSIONS REDUCTION

EPA's proposed Phase II standards (see below) would control nationwide VOC emissions from TSDFs by 94 percent, reducing emissions to 110,000 Mg/year (120,000 tons/year). The standards would apply to tanks, surface impoundments and containers having volatile organic concentrations greater than or equal to 500 parts per million weight (ppmw).

COST EFFECTIVENESS

The total nationwide capital investment necessary to implement EPA's proposed Phase II standards at TSDFs is estimated at about \$960 million, or approximately \$360 million annually. Cost effectiveness is therefore \$360 million/1.7 million Mg, or \$212/Mg (\$191/ton).

FEDERAL RULEMAKING AND/OR GUIDANCE DOCUMENTS

EPA is taking several separate actions to address VOC emissions at TSDFs, due to the wide variety of TSDF

STAPPA/ALAPCO Recommendation

► Once EPA publishes its hazardous waste rules, it will be incumbent upon state hazardous waste officials to upgrade permits. As a result, significant additional emissions reductions can be expected from TSDFs. Air agencies should coordinate with state hazardous waste officials to expedite this process and may wish to adopt separate air pollution control regulations for TSDFs, modeled after EPA's proposal. EPA's final rules are expected to be published in the spring 1994.

sources and the complex analyses required to assess emissions from these sources. On June 21, 1990, EPA promulgated Phase I standards for the control of emissions from process vents and equipment leaks (55 FR 25454). On July 22, 1991, EPA proposed Phase II organic air emissions standards for tanks, surface impoundments and containers having volatile organic concentrations greater than or equal to 500 ppmw (56 FR 33490). The final rule is expected to be issued in the spring of 1994 and to take effect 30 days later. Phase III regulations to address the remaining residual risk from TSDF emissions are expected to be developed at a later date.

❖ *For more information on the proposed rule, contact Michelle Aston, U.S. Environmental Protection Agency, Emissions Standards Division (MD-13), Research Triangle Park, NC 27711 (telephone: 919/541-2363).*

STATE AND LOCAL CONTROL EFFORTS

In Indiana, TSDFs are controlled by strategies such as incineration, permitting and Best Available Control Technology.

REFERENCES

1. Lake Michigan Air Directors Consortium. April 1993. *Evaluation of Possible Control Measures for Control of*

(VOC) Emissions From Treatment, Storage and Disposal Facilities (TSDF). Draft.

2. U.S. Environmental Protection Agency. July 22, 1991. *Hazardous Waste Treatment, Storage, and Disposal Facilities; Organic Air Emission Standards for Tanks, Surface Impoundments, and Containers*. Proposed Rule. 57 Federal Register 33490.
3. U.S. Environmental Protection Agency. September 18, 1992. *Hazardous Waste Treatment, Storage, and Disposal Facilities; Organic Air Emission Standards for Tanks, Surface Impoundments, and Containers*. Notice of Data Availability. 57 Federal Register 43171.

Table 1

Summary Table – Treatment, Storage and Disposal Facilities

Affected Facilities	Stationary and mobile TSDFs with VOC concentrations greater than 500 ppmw.
Number of Affected Facilities	2,331 facilities nationwide.
National Emissions Estimates	1.8 million Mg per year (2.0 million tons per year).
100 TPY Source Size	The average TSDF has annual emissions of 858 tons per year.
Potential Emissions Per Facility Reduction	94 percent VOC reduction.
Cost Effectiveness	Capital costs = \$960 million Annual costs = \$360 million Cost Effectiveness = \$212/Mg (\$191/ton)
Federal Rulemaking and/or Guidance Documents	Phase I regulations covering process vents and equipment leaks promulgated June 21, 1990. Phase II regulations, to include emissions standards for tanks, surface impoundments and containers with volatile organic concentrations greater than or equal to 500 ppmw, expected to be promulgated in the spring of 1994.
STAPPA/ALAPCO Recommendation	Once EPA publishes its hazardous waste rules, it will be incumbent upon state hazardous waste officials to upgrade permits. As a result, significant additional emissions reductions can be expected from TSDFs. Air agencies should coordinate with state hazardous waste officials to expedite this process and may wish to adopt separate air pollution control regulations for TSDFs, modeled after EPA's proposal. EPA's final rules are expected to be published in the spring of 1994.

Underground Storage Tank Vents

DESCRIPTION OF SOURCE CATEGORY

In most cases, gasoline that is dispensed into motor vehicles is stored in underground tanks at service stations. Gasoline tank capacity ranges in size from 250 gallons to more than 10,000 gallons. Fire marshal regulations require that these tanks be vented, typically specifying a vent release point 12 feet above ground to prevent heavier-than-air gasoline vapors from accumulating at ground level. Each tank must have a vent; however, the outlets can be manifolded together above ground to reduce the number of release points.

In uncontrolled situations, vapors are emitted through the vent primarily as a result of displacement during tank loading. Emissions also occur as a result of changes in temperature and barometric pressure. Stage I controls were intended to control emissions from vents during tank loading operations by channeling displacement vapors into the delivery truck through pipes and hoses.

A study conducted by the Bay Area Air Quality Management District (BAAQMD), however, concluded that, even with Stage I controls, emissions can still occur from the vents. Typically, a delivery truck arrives at a service station with its load under approximately 25 inches of water

pressure. When the vapor hose is connected between the truck and the underground tank, the pressure in the truck tank decreases while the pressure in the underground tank increases, until the two reach equilibrium. The increase in the underground tank pressure results in emissions at the vent.

GEOGRAPHIC DISTRIBUTION OF SOURCES

There are approximately 420,000 gasoline dispensing facilities distributed throughout the country. The number of storage tanks at each facility will vary widely, although, typically, each facility has between one and four gasoline tanks.

Gasoline consumption, which generally follows population distribution, is also a key factor in estimating emissions. In 1990, nationwide gasoline consumption totaled more than 116 billion gallons, with approximately 50.3 billion gallons consumed in Moderate and above ozone nonattainment areas.

NATIONAL EMISSIONS ESTIMATES

BAAQMD estimated emissions caused by diurnal temperature and barometric pressure changes at 0.10 pounds of

STAPPA/ALAPCO Recommendation

► The installation of a P-V valve on the open vent pipes of any storage tank equipped with a Stage I vapor recovery system is Reasonably Available Control Technology. Such P-V valves should be set at 2.5 to 3 inches water column for pressure relief and 6 inches of water column for vacuum.

volatile organic compounds (VOCs) per 1,000 gallons transferred. This release rate yields a nationwide emissions estimate of 5,800 tons per year and a nonattainment area emissions estimate of 2,500 tons per year for emissions caused by temperature and barometric pressure changes.

In addition, the BAAQMD also estimated emissions of 0.475 pounds per 1,000 gallons transferred for losses with Stage I when the truck pressure equalizes with the underground tank. Stage I controls at service stations are required in all nonattainment areas, but not elsewhere. Total nonattainment area emissions from pressure equalization during tank loading are estimated at 11,850 tons per year.

For emissions inventory purposes, BAAQMD used emission factors developed by the California Air Resources Board (CARB); these factors are included in CARB's *Report to the Legislature on Vapor Recovery Systems for Vehicle Fueling at Service Stations*.

AVAILABLE CONTROL STRATEGIES

Pressure-vacuum (P-V) vents can be installed on underground tank vent lines to maintain pressure within the tank. The P-V vent has weights or springs to restrict outward or inward venting until the set pressure has been reached. Such P-V vents have been in use for many years and are available from several manufacturers. According to BAAQMD, at least five manufacturers have P-V vents that have passed California's vapor recovery certification requirements.

Generally, a 100-percent reduction could potentially be achieved in emissions caused by diurnal temperature

and barometric changes and Stage I pressure equalization. [Note: The potential emissions reduction may fall to 99.5 percent due to seepage through the valve, which may occur during high $\Delta P_b/P_{\text{tank}}$ periods.] BAAQMD is conducting additional testing to determine whether P-V vents will increase Stage II efficiency. The agency estimates that, currently, efficiency increases in Stage II of 1 percent might be attributable to P-V vents.

POTENTIAL NATIONAL EMISSIONS REDUCTION

The installation of P-V vents on underground tank vents should eliminate diurnal temperature/barometric pressure losses and pressure equalization losses. The potential emissions reductions would therefore be equal to the emissions estimates identified above. Additional emissions reductions could occur in areas that require Stage I vapor recovery at service stations outside of nonattainment areas.

BAAQMD is conducting additional testing to determine if P-V vents could also increase the efficiency of Stage II vapor recovery systems and estimates that P-V vents could increase the efficiency of Stage II systems by 1 percent.

COST EFFECTIVENESS

Costs will vary depending on the number of underground tanks, whether the vents are manifolded and the individual P-V valve cost. A typical case may be a facility with four non-manifolded underground tank vents and requiring four P-V valves. Capital costs for such a facility would range from \$48 to \$72, depending upon the type of P-V valve selected.

BAAQMD calculated a cost effectiveness of \$10 to \$20 per ton of VOCs reduced. This cost did not include savings associated with gasoline recovery estimated at about 100 gallons per year.

FEDERAL RULEMAKING AND/OR GUIDANCE DOCUMENTS

The U.S. Environmental Protection Agency (EPA) developed a guidance document for Stage I underground storage tank controls in 1975. Implementation of this guidance by most states did not include a requirement for the installation of P-V valves.

STATE AND LOCAL CONTROL EFFORTS

Most states have incorporated submerged fill in all tanks in nonattainment areas and require Stage I controls at facilities with throughputs greater than 10,000 gallons/month or

on tanks having a capacity greater than 2,000 gallons. In addition, a few states currently require P-V valves at all service stations. Where Stage II controls are mandated, vacuum-assisted Stage II systems are required to have P-V valves.

In October 1990, BAAQMD revised its Stage I rules for gasoline dispensing facilities (Regulation 8, Rule 7, Section 8-7-301.4) to include a requirement for P-V vents.

The South Coast Air Quality Management District (SCAQMD) is currently amending its rule on gasoline storage and dispensing to require that underground gasoline storage tanks be equipped with P-V valves on the vent tubes; this measure has been included in the State Implementation Plan. It is estimated that the rule will reduce VOC emissions in Los Angeles by 1 to 2 tons per day. SCAQMD's efforts related to P-V devices is modeled after the efforts of BAAQMD.

REFERENCES

1. Lake Michigan Air Directors Consortium. April 1993. *Control of Emissions From Service Stations Tank Breathing*.
2. California Air Resources Board. March 1983. *Report to the Legislature on Vapor Recovery Systems for Vehicle Fueling at Service Stations*.

Table 1
Summary Table – Underground Storage Tank Vents

Affected Facilities	Any gasoline storage tank with an uncontrolled vent to the atmosphere.			
Number of Affected Facilities	420,000 nationwide, assuming no exemptions (1990 estimate).			
National Emissions Estimates	Nationwide VOC emissions from diurnal temperature/barometric pressure changes estimated at 5,800 tons/year. Emissions from pressure equalization at Stage I facilities in nonattainment areas estimated at 11,850 tons/year.			
VOC Emissions Range Per Facility	Size	Small	Medium	Large
	Gasoline throughput, gallons/month	6,000	35,000	185,000
	Temp/pressure changes, tons/yr	0.003	0.02	0.1
	Stage I equalization, tons/yr	0.02	0.1	0.5
Potential Emissions Reduction Per Facility	100-percent VOC reduction.			
Cost Effectiveness	Basis: Facility with four tank vents requiring four P-V vents Capital costs: \$48 to \$72 per valve Cost effectiveness: \$10 to \$20 per ton			
Federal Rulemaking and/or Guidance Documents	Guidance for Stage I underground tank controls was issued in 1975.			
State and Local Control Efforts	Most states have incorporated submerged fill in all tanks in nonattainment areas and require Stage I controls at facilities with throughputs greater than 10,000 gallons/month or on tanks having a capacity greater than 2,000 gallons. Some states currently require P-V valves on all service stations, but most do not. Where Stage II is mandated, vacuum-assisted Stage II systems require P-V valves. In October 1990, BAAQMD revised its Stage I rules to require P-V valves at gasoline dispensing facilities.			
STAPPA/ALAPCO Recommendation	Require installation of P-V valves on the open vent pipes of storage tanks equipped with Stage I vapor recovery. Set valves at 2.5 to 3 inches water column for pressure relief and 6 inches of water column for vacuum.			

Volatile Organic Liquids Storage

DESCRIPTION OF SOURCE CATEGORY

Bulk volatile organic liquids (VOLs) are typically stored in vertical or horizontal tanks. Volatile organic compounds (VOCs) are emitted through tank breathing or diffusional losses, which result from changes in ambient air temperature and barometric pressure, and through liquid working losses, which result from the displacement of vapors as tanks are filled. Total losses are the sum of breathing and working losses.

Factors that affect total losses include the liquid's vapor pressure, the wind velocity, the type of roof seal on the tank, the color of the tank and temperature changes.

Industries with large numbers of storage tanks include petroleum distribution (e.g., petroleum refineries, pipelines and gasoline terminals) and chemical plants, among others.

GEOGRAPHIC DISTRIBUTION OF SOURCES

VOL storage tanks are located throughout the United States, with concentrations found in coastal cities with marine terminals and industrial centers with extensive storage and distribution facilities.

NATIONAL EMISSIONS ESTIMATES

Table 1 shows national emissions estimates for tanks with capacities over 40,000 gallons, with two tank configurations and three vapor pressure ranges.

AVAILABLE CONTROL STRATEGIES

VOC emissions from VOL storage tanks can be controlled by sealing the tanks to prevent emissions or by collecting VOL vapors for recovery or destruction.

Tank Seals: Different sealing approaches are used for each of the three main types of tanks – fixed-roof, internal floating-roof and external floating-roof.

- For fixed roof tanks, working and breathing losses can be controlled by installing an internal floating roof with appropriate fittings and seal system; installing and using a vapor recovery system, such as carbon adsorption or refrigerated condensation; and installing and using a vapor oxidation control system (i.e., flare, thermal incinerator or catalytic incinerator).
- Internal floating roof (IFR) tanks using a rim seal system emit fewer VOCs per unit of storage than

fixed roof tanks. An IFR can be installed in a fixed roof tank as a control technique, reducing emissions by 69 percent to 98 percent, depending on turnovers, tank volume, the liquid being stored and the type of seal system used. The IFR reduces evaporative losses by acting as a vapor barrier that precludes direct contact between large areas of the liquid surface and the atmosphere. There are various floating roof designs; their effectiveness is a function of how well the floating roof is sealed. Losses can occur from IFR tanks in various ways. Table 2 provides an example of the distribution of losses from IFR tanks. With the exception of withdrawal losses, most of these losses can be reduced by using alternative design features. Fitting losses occur when liquid penetrates through necessary openings in the floating roof. Closer tolerances in fabrication, gaskets and seals can control most fitting losses. Seal losses occur between the edge of the floating roof and the wall of the storage tank. This space can be sealed with vapor-mounted seals or liquid-mounted seals, the latter of which are more effective in reducing VOC emissions. Liquid- or vapor-mounted seal performance can be improved by adding a secondary seal system. Because bolted sheets or panels are prone to develop deck seam leaks, deck seam losses are inherent in several floating roof designs. Deck seam leaks are a function of the total length of the seam, rather than the type of seam. By welding seams, rather than bolting them, this problem can be eliminated.

- External floating roofs (EFRs) are usually constructed of welded steel and have a shoe-type primary seal. The shoe seal is a sleeve of steel that is attached to the floating roof and is forced against the vertical, inside edge of the storage tank. The shoe slides up and down with the roof. Since most EFRs are of welded construction, there are no deck seam losses, leaving only rim, fitting and withdrawal losses. Estimated losses from EFR tanks are shown in Table 3; controls for these losses are the same as for IFR tanks.

Vapor Removal/Destruction for Fixed Roof Tanks:

When fixed roof tanks are filled, vapors in the vapor space are displaced by the incoming liquid. VOC emissions can be controlled by carbon adsorption or by thermal or catalytic oxidation.

- Carbon adsorption takes advantage of carbon's affinity for nonpolar hydrocarbons to remove VOCs from tank emissions. VOCs are adsorbed

STAPPA/ALAPCO Recommendation

► Current storage tank rules generally exempt tanks of less than 40,000 gallons and liquids with a vapor pressure of 1.5 psia or less. The 1.5 psia cut-point was established to assure that crude oil and gasoline storage would be covered and most other chemicals would be exempt. Control of other VOL can be achieved by lowering vapor pressure exemptions from 1.5 psia to 0.5 psia.

Existing state and local rules can be enhanced by incorporating provisions for test methods, monitoring specifications and equipment specifications from the proposed HON storage rule and the draft CTG for VOL storage.

onto the surface of the adsorbent, usually a bed of activated carbon. A bed is used until it reaches equilibrium with the vapors and is then regenerated while another bed is used. The spent bed is regenerated by steam extraction or high vacuum extraction. Vaporized VOCs are condensed, separated and returned to the storage tank. Although technically feasible, carbon adsorption is not generally used to control VOL tank emissions.

- Oxidation units using a thermal or catalytic incinerator or flare can destroy VOC emissions from a fixed roof storage tank. VOC emissions are injected via a burner manifold into the combustion zone of an incinerator. Natural gas pilot burners provide the ignition source and back-up natural gas is supplied as supplemental fuel, if needed. A major advantage of the thermal oxidizer is that it can destroy a wide range of VOCs.

POTENTIAL NATIONAL EMISSIONS REDUCTION

Table 4 presents estimated potential national VOC emissions reductions (based upon vapor pressure) for all tanks.

greater than 40,000 gallons, excluding gasoline storage tanks. The U.S. Environmental Protection Agency's (EPA's) draft Control Techniques Guideline (CTG) document used New Source Performance Standard (NSPS) data to estimate emissions reductions.

Implementation of Reasonably Available Control Technology (RACT) on VOL storage tanks only in ozone nonattainment areas would reduce VOC emissions by about 64,200 megagrams per year (Mg/yr) (70,800 tons per year). This estimate does not include tanks at coke oven by-product plants; pressure tanks operating over 204.9 kilopascals (kPa); tanks attached to mobile vehicles; tanks at bulk gasoline plants; tanks at service stations; tanks used to store beverage alcohol; or tanks used prior to custody transfer for petroleum products less than 420,000 gallons.

COST EFFECTIVENESS

Table 5 shows the cost effectiveness of implementing RACT on tanks with a capacity of more than 40,000 gallons. The figures are based on the tank models developed for EPA's draft CTG. Implementation of RACT only in ozone nonattainment areas would cost approximately \$31 million. The average cost effectiveness would be approximately \$490 per Mg VOC reduced (\$440 per ton).

The Federal Implementation Plan for Chicago reported a cost effectiveness of \$120 per ton of VOC reduced, with emphasis on retrofitting all fixed roof tanks with floating roofs.

FEDERAL RULEMAKING AND/OR GUIDANCE DOCUMENTS

EPA has prepared two technical guidance documents with sections on RACT implementation and a model rule. The agency also has promulgated three NSPSs, which establish the major components of the regulatory baseline.

As a result of these previous technical guidance documents, all fixed-roof tanks with volumes of 40,000 gallons or more and storing liquids with true vapor pressure of 1.5 pounds per square inch actual (psia) or greater are currently controlled.

The draft CTG for VOL storage is now undergoing review by the Office of Management and Budget and is expected to be published by the summer of 1993.

❖ For more information, contact Mark Morris, U.S. Environmental Protection Agency, Emission Standards Division (MD-13), Research Triangle Park, NC 27711 (telephone: 919/541-5416).

STATE AND LOCAL CONTROL EFFORTS

Most agencies have adopted rules for VOL storage facilities. The following are examples of these rules.

Wisconsin has implemented regulations pertaining to the storage of organic compounds and petroleum products. These include Rules 419.05, 420.03 and 440.285, which set guidelines for external and internal floating roof tanks. In addition, NR445.004 and 445.05 set Lowest Achievable Emission Rates for hazardous air pollutants (HAPs), including benzene, for new and existing facilities. Gasoline storage facilities are subject to this additional regulatory emission limitation, since gasoline contains benzene, which is listed as a HAP in Section 112 of the Clean Air Act.

Rule 4, Article 8 of Title 326 of the Indiana Administrative Code (326 IAC 8-4) addresses VOL storage in Indiana. The rule requires retrofitting of fixed roof tanks with internal floating roofs and retrofitting of open-top tanks with external floating roofs for tanks larger than 39,000 gallons containing liquids with a vapor pressure greater than 1.52 psia. The use of equally effective alternative controls is allowed.

In Michigan, Rules 604 and 605 regulate the storage of organic compounds in vessels with a capacity of more than 40,000 gallons and containing liquids with vapor pressures greater than 1.5 psia. Such vessels must be equipped with vapor recovery systems that recover at least 90 percent by weight of the uncontrolled organic vapor.

New York adopted the draft CTG requirements for VOL storage in the 1993 Part 229 revisions.

The South Coast Air Quality Management District's (SCAQMD's) Rule 463 regulates storage of organic liquids. The rule specifies such things as seal design and floating roofs, among others, for specific situations. As a result of the success of a one-year pilot program, a proposed amendment to Rule 463 will include a tank self-inspection program under which selected operator staff will be certified by SCAQMD to carry out tank inspections in accordance with an approved inspection and maintenance plan.

REFERENCES

1. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. July 1992. *Control of Volatile Organic Compound Emissions From Volatile Organic Liquid Storage in Floating and fixed Roof Tanks*. Draft.

2. Lake Michigan Air Directors Consortium. April 16, 1993. *Control of Emissions From VOC Storage Facilities*. Draft.

Table 1

National VOC Emissions^a

Vapor Pressure Cutoff Options (psia)	Losses From Fixed Roof Tank		Emissions Above Cutoff Options Internal Floating Roof Tank	
	Mg/yr	(tpy)	Mg/yr	(tpy)
0.5	54,690	(60,300)	16,430	(18,100)
0.75	50,470	(55,600)	16,260	(17,900)
1.0	44,170	(48,700)	16,010	(17,650)
TOTAL	153,330	(169,000)	48,700	(53,700)

^a See Reference 1.

Table 2

Example of Losses from IFR Tanks^a

Source	Percent of Total Losses
Rim (or seal) losses	35
Fitting losses	35
Deck seam losses	18
Withdrawal losses	12

^a See Reference 1.

Table 3

Losses from External Floating Roof Tanks^a

Source	Percent of Total Losses
Rim (or seal) losses	68
Fitting losses	28
Withdrawal losses	4

^a See Reference 1.

Table 4

National Emissions Reduction^a

Lower Cut-off Volume (gallons)	Vapor Pressure (psia)	Emission Reduction	
		Mg/yr	tons/yr
40,000	0.5	68,450	75,500
40,000	0.75	64,260	70,800
40,000	1.0	57,850	63,800
TOTAL		190,560	210,100

^a See Reference 1.

Table 5

Cost Effectiveness of Emission Controls^a

Vapor Pressure (psia)	Nationwide Capital (\$millions)	Nationwide Annual Cost (\$millions)	Cost Effectiveness		Incremental Cost Effectiveness	
			\$/Mg	\$/ton	\$/Mg	\$/ton
0.5	337.3	38.4	560	510	1,690	1,530
0.7	5275.3	31.3	490	440	1,080	980
1.0	214.4	24.4	420	380	N/A	N/A

^a See Reference 1.

Table 6

Summary Table – Volatile Organic Liquids Storage

Affected Facilities	Tanks storing VOL.			
Number of Affected Facilities ^a	The total number of tanks affected is 55,200: 13 percent fixed roof, 41 percent internal floating roof and 46 percent external floating roof tanks.			
National Emissions Estimates	Nationwide VOC emissions for fixed and internal floating roof tanks are 218,600 tons/year. Data was not available for external floating roof tanks.			
VOC Emissions Range Per Facility	Vapor Pressure (psia)			
		0.5	0.75	1.0
	Fixed Roof	60,770 tpy	56,080 tpy	49,080 tpy
	Internal Floating	18,070 tpy	17,890 tpy	17,610 tpy
	External Floating	DATA NOT AVAILABLE		
Cost Effectiveness	Vapor Pressure (psia)			
		0.5	0.75	1.0
	Fixed Roof			
	per ton VOC	\$530	\$460	\$380
	Internal Floating			
per ton VOC	\$1,850	\$1,780	\$1,750	
External Floating				
per ton VOC ^a	-\$90	-\$120	-\$160	
Federal Rulemaking and/or Guidance Documents	Draft CTG and model rule in process; EPA has also published two CTGs and three NSPS.			
State and Local Control Efforts	Many states have rules concerning VOL storage.			
STAPPA/ALAPCO Recommendation	Consider lowering 1.5 psia exemption to 0.5 psia and enhancing test methods, monitoring specifications and equipment specifications based upon the draft HON rule and VOL storage CTG.			

^aAnnual operating costs are more than offset by savings in product recovered.

Whiskey Distilleries

DESCRIPTION OF SOURCE CATEGORY

The manufacture of whiskey involves two distinct steps: the production of unaged whiskey from cereal grains and the maturation of this whiskey by storage in barrels.

In the production of unaged whiskey, grain is first milled, then cooked in water to solubilize the starches. The solubilized starches are then mixed with partially germinated grain. This step results in the starches being hydrolyzed to sugars by the enzymes in the germinated grain. The sugars are then fermented with yeast and the resulting mixture is distilled to produce unaged whiskey. This production process is responsible for only a small percentage of the volatile organic compounds (VOCs) emitted in whiskey manufacturing.

The unaged whiskey, colorless and pungent tasting, must be stored in charred oak barrels to produce the alcoholic beverage with the traditional characteristics of whiskey. During this period, the alcohol absorbs and reacts with constituents in the barrel wood and gains the distinctive taste and aroma of whiskey. This process is known as aging or maturation. During the aging period, ethanol and water seep through the barrel and evaporate into the air. Also, when the barrels are emptied to bottle the whiskey,

ethanol and water remaining in the barrel wood evaporate into the air. These last two phenomena are the major sources of VOC emissions in whiskey production.

GEOGRAPHIC DISTRIBUTION OF SOURCES

Five states manufactured approximately 90 percent of the whiskey produced in the United States in 1976. They include Kentucky, Indiana, Illinois, Tennessee and Maryland.

NATIONAL EMISSIONS ESTIMATES

Based on 1976 data, EPA has estimated total VOC emissions from the five states mentioned above. These estimates are shown in Table 1. The national VOC emissions estimate was 42,100 tons/yr, based on an emission factor of 0.2 pound ethanol per pound stored and a total of 11.9 million barrels stored in June 1976.

AVAILABLE CONTROL STRATEGIES

The U.S. Environmental Protection Agency (EPA) investigated two methods for reducing warehouse VOC emis-

sions. These included the installation of a carbon adsorption unit and the use of an alternate aging system.

Controlling warehouse emissions by carbon adsorption involves closing the warehouse and ducting the interior air to a carbon adsorption unit. The carbon adsorption unit is a skid-mounted package system containing two beds, fans, switching mechanisms and controls, a condenser/decanter and internal piping for steam and airflow. The unit is run on a two-cycle system with one bed adsorbing as the second is regenerated and cooled.

A second method of controlling VOC emissions from whiskey aging involves the maturation of whiskey in closed stainless steel vessels lined with straight charred staves. This type of control system has generated interest due to its potential for significant savings in aging costs and for almost complete elimination of aging losses. Its applicability will depend on the system's ability to produce whiskey of acceptable quality.

The central component of the system is a cylindrical stainless steel vessel approximately five meters in diameter and seven meters high, holding approximately 100,000 liters of liquid. Inside the vessel, straight charred oak staves are held in the whiskey by arms that extend radially from a shaft at the center of the vessel. The staves are arranged so that air spaces created between them are manifolded together to the central shaft holding the arms and from there to vacuum pressure and condensing equipment. The central shaft can be designed to rotate in order to move the staves through the whiskey. The vacuum equipment pulls vapors through the staves to simulate aging; the condenser recovers this vapor as liquid and returns it to the vessel. The pressure equipment provides for further controls over the aging process, potentially useful in producing whiskey of a desired quality. Finally, internal heating coils provide for temperature control of the aging whiskey.

POTENTIAL NATIONAL EMISSIONS REDUCTION

EPA calculated potential national VOC emissions reductions by assuming an 85-percent control efficiency using carbon adsorption. Using the 1976 total VOC emissions estimate in conjunction with 85-percent control, VOC emissions would be reduced 35,800 tons per year.

EPA estimates an 85-percent recovery efficiency with a carbon adsorption flow capacity of one and a half times that based on warehouse mass balance. It is expected that greater efficiencies could be obtained in many cases.

Maturation of whiskey in stainless steel vessels has the potential to completely eliminate whiskey loss. Loss during aging is eliminated since ethanol evaporating through the staves is captured in the air spaces manifolded to the condensers, which return the vapor as liquid to the

STAPPA/ALAPCO Recommendation

► State and local agencies should consider requiring carbon adsorption at a capture and control level of no less than 85 percent to reduce VOC emissions from whiskey distilleries.

vessel. Soakage losses are reduced since the alcohol remaining in the staves is partially recovered by continuing to draw a vacuum after the whiskey is emptied. The vacuum evaporates the ethanol in the staves and draws it to the condensers where ethanol is recovered. Finally, any losses due to spillage and barrel leaks are eliminated since the whiskey is piped into and out of the aging vessels.

The key factor in evaluating the system's applicability is the quality of whiskey produced. Industry leaders contend that whiskey quality could be harmed if the carbon adsorption system altered such warehouse conditions as temperature, humidity and ventilation. Changes in these conditions could affect the various physical and chemical processes involved in whiskey aging and evaporation, such as the diffusion of water and ethanol through the wood, the transfer of wood constituents into the whiskey and the chemical reactions occurring in the wood and the whiskey. In one full-scale test of the control system, whiskey quality was lowered and the test was discontinued. However, analysis of the test indicated that certain design and operating changes could eliminate the observed quality problems.

COST EFFECTIVENESS

According to U.S. Environmental Protection Agency (EPA) estimates, cost effectiveness ranges from a credit of \$130 per ton of VOCs reduced to a cost of \$220 per ton of VOCs reduced, depending on the size of the warehouse and the degree of ethanol concentration.

FEDERAL RULEMAKING AND/OR GUIDANCE DOCUMENTS

In 1978, EPA published a study on whiskey warehousing.

STATE AND LOCAL CONTROL EFFORTS

The Jefferson County Air Pollution Control District in Louisville, Kentucky has conducted a State Implementation Plan (SIP) control strategy evaluation of whiskey warehousing operations. The proposed strategy involves moving whiskey warehousing operations out of Jefferson County; both the feasibility and the cost effectiveness of the proposal were examined.

REFERENCES

1. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. April 1978. *Cost and Engineering Study - Control of Volatile Organic Emissions from Whiskey Warehousing*. EPA-450/2-78-013.

Table 1.....

Emission Estimates by State^a

State	No. of Barrels in Storage June 1976	Total Emissions ^b (tons/yr)
Kentucky	6,130,000	21,600
Illinois	1,290,000	4,540
Indiana	2,260,000	7,960
Maryland	640,000	2,260
Tennessee	580,000	1,960

^a See Reference 1.

^b Represents approximately 90 percent of total national emissions.

Table 2.....

Summary Table - Whiskey Distilleries

Affected Facilities	Any facility that produces unaged whiskey from cereal grains and in which the maturation of whiskey takes place in charred oak barrels.
Number of Affected Facilities	In 1990, 62 facilities were listed in SIC Code 2085 (Distillation and Blended Liquors).
National Emissions Estimates	Nationwide VOC emissions were 42,100 tons/year in 1976.
VOC Emissions Range Per Facility	EPA has indicated that model plant sizes range from 50 to 400 tpy.
Potential Emissions Reduction Per Facility	85 percent with carbon adsorption.
Cost Effectiveness	EPA developed control costs for six model plants. Cost effectiveness ranged from a net credit of \$130 per ton of VOC reduced to a cost of \$220 per ton of VOC reduced.
State and Local Control Efforts	Jefferson County, KY SIP control strategy proposed relocating whiskey warehousing operations out of the county.
STAPPA/ALAPCO Recommendation	Require carbon adsorption at no less than 85-percent capture and control level.

Wood Furniture Coating

DESCRIPTION OF SOURCE CATEGORY

The wood furniture industry is characterized by a large number of small plants typically producing wood household furniture, kitchen cabinets, television cabinets, office furniture and store fixtures. There are over 11,000 facilities engaged in furniture finishing, with 86 percent of them employing fewer than 50 workers each. The total number of employees in the furniture business is approximately 390,400.

The primary methods used to coat wood furniture are flat line finishing and spray coating, the latter being the most commonly used. A complex series of coating steps and application methods is involved in finishing wood products. In general, coatings are applied in the following order: stain, wash coat, filler, sealer, highlight coat and top-coat. Emissions occur primarily from the solvents used during the coating process.

GEOGRAPHIC DISTRIBUTION OF SOURCES

As shown in Table 1, wood finishing facilities are located in every EPA region, with the greatest number in Region IV.

NATIONAL EMISSIONS ESTIMATES

In 1989, approximately 135,000 tons of solvents were used for wood furniture and fixtures nationwide. Estimated emissions of volatile organic compounds (VOCs) in ozone nonattainment areas were about 90,000 tons.

It is reasonable to assume that all of the solvents used eventually reach the atmosphere. According to EPA, the hazardous air pollutant chemicals contained in these solvents in the greatest amounts are toluene at 26 percent, xylene at 15 percent, methyl ethyl ketone at 5.5 percent, methyl isobutyl ketone at 7.3 percent and glycol ether and esters at 1.7 percent.

AVAILABLE CONTROL STRATEGIES

There are four major categories of control strategies that can be used to reduce VOC emissions from furniture finishing operations, including 1) add-on control devices, 2) low-solvent reformulated coatings, 3) emerging technologies and 4) improved work practices.

Add-on Control Devices: Add-on control devices are incorporated into a process to remove or destroy VOCs in the emissions. There are three add-on control methods – thermal oxidation, catalytic oxidation and adsorption.

■ Thermal oxidation involves heating VOC contaminants to their autoignition temperatures in the presence of sufficient oxygen to affect complete destruction. Although chemicals have different autoignition temperatures, incinerators are usually operated at a single temperature that will result in the efficient destruction of most VOCs found in the stream. Factors affecting incinerator performance are residence time in the combustion zone, mixing and incinerator temperature. A thermal incinerator is typically comprised of a refractory-lined chamber with gas burners at one end. The chamber is sized to allow a residence time of 0.3 to 1.0 second at the maximum gas flow rate. Using flue gases to preheat combustion air and/or vent gases is a common method of heat recovery. However, if a heat recovery process is used, insurance regulations require that VOC concentrations be kept below 25 percent of the lower explosive limit (LEL) to prevent explosion hazards. Test results demonstrate that thermal oxidizers can achieve a 98-percent VOC destruction efficiency for most VOCs at combustion chamber temperatures ranging from 700°C to 1300°C and residence times of 0.5 to 1.5 seconds.

■ Catalytic oxidation introduces a catalyst to dramatically increase the rate of the chemical reaction between the VOCs and the oxygen; the catalyst itself is not altered during the reaction. The increased reaction rate can greatly reduce the autoignition temperature, which, in turn, reduces the minimum combustion chamber temperature, typically to a range of 260°C to 427°C. The reduced temperatures result in significant fuel savings when compared to a thermal incinerator. Catalytic incinerators can also process dilute VOC streams in which the concentration of VOCs is well below the LEL; this can be an advantage for some processes. Disadvantages of catalytic units include higher installation costs and the possibility of catalyst poisoning by sulfur, metals and phosphorous. Overall destruction efficiency is dependent upon space velocity, operating temperature, oxygen concentration and VOC composition and concentration. Under the proper conditions, a catalytic unit can achieve 95-percent VOC destruction efficiency.

■ Adsorption is a mass-transfer operation involving the conversion of VOCs from a gas phase to a solid phase. The most common adsorption system uses activated carbon, which is effective in capturing

most VOCs through a physical adsorption mechanism. In addition, activated carbon can be regenerated by steam or nitrogen stripping or high-vacuum regeneration. At a minimum, two adsorption beds and a regeneration facility are required for an adsorption process. In practice, process vent emissions are directed to the first adsorption bed until equilibrium is reached. The emissions are then directed to the second adsorption unit while the first unit is being regenerated; the run time on a unit must be longer than the regeneration cycle. Removal efficiency by adsorbers can be as high as 95 percent for certain chemicals.

Low-solvent Reformulated Coatings: In wood furniture finishing operations, VOC emissions result from the application and subsequent evaporation of the finishing materials. The use of reformulated coatings that contain non-volatile solvents will reduce VOC emissions. Currently, most of the low-VOC reformulated coating alternatives available are clear coats, which could potentially be used to replace nitrocellulose clear lacquer coats in the finishing process. Reformulated coatings include waterborne, catalyzed ultra-violet (UV) curable, polyester polyurethane and the UnicarbR system coating.

Emerging Technologies: Currently, efforts are underway to improve several technologies that have potential applications in the wood furniture industry. These developments include advances in booth design that will reduce the volume of air exhausted, new curing methods that involve three-dimensional UV curing and research into biofiltration that will improve add-on controls.

Improved Work Practices: Improved work practices, such as employing high transfer efficiency application methods and reducing the volume of clean-up solvent, can lower VOC emissions by minimizing the quantity of VOC-containing materials used.

POTENTIAL NATIONAL EMISSIONS REDUCTION

As depicted in Table 2, the potential for emission reductions from the wood furniture coating industry is significant, with estimates ranging from approximately 64,000 to 95,000 megagrams (Mg) per year, depending upon the Reasonably Available Control Technology (RACT) option selected.

EPA has developed 11 model plants to characterize wood finishing operations. These models depict various finishing sequences, application methods, plant sizes and VOC usage scenarios. The information used to develop these models was compiled based upon plant visits and

information requests under Section 114 of the Clean Air Act.

Currently, EPA is revising information related to the wood furniture coating industry as part of a regulatory negotiation to develop a National Emission Standard for Hazardous Air Pollutants (NESHAP) under Section 112 and a Control Techniques Guideline (CTG) for this industry. The actual level of reductions to be achieved will depend upon the strategy that is ultimately required.

COST EFFECTIVENESS

Total estimated costs for installing RACT on the wood furniture coating industry range from \$147 million to \$418 million, depending upon the RACT option selected, with cost effectiveness ranging from \$2,007 to \$6,514 per Mg of VOC removed.

EPA presented cost information at its 1991 National Air Pollutant Control Technical Advisory Committee meeting, while industry has generated its own assessment of the impacts. Information related to cost effectiveness is also being reviewed as part of the regulatory negotiation.

FEDERAL RULEMAKING AND/OR GUIDANCE DOCUMENTS

EPA is currently involved in negotiations with state and local air pollution control agencies, industry and environmental groups to develop a NESHAP and CTG for the wood furniture manufacturing industry. Because many of the VOCs emitted in furniture coating operations are also hazardous air pollutants, the CTG and NESHAP development efforts are being coordinated in order to ensure consistency between the rules. Final regulations are not expected to be promulgated until next year.

❖ *For more information, contact Madeleine Strum, U.S. Environmental Protection Agency, Emission Standards Division (MD-13), Research Triangle Park, NC 27711 (telephone: 919/541-2383).*

STATE AND LOCAL CONTROL EFFORTS

Illinois regulates large wood furniture coaters (i.e., those that emit more than 100 tons per year of VOCs) in the Chicago nonattainment area (Ill. APR, Title 35, Section 218.24[1]).

Indiana's 326 IAC 8-2-17 applies to coated wood furnishers in Clark, Elkhart, Floyd, Lake, Marion, Porter and St. Joseph counties that emit 15 pounds or more of VOCs per day, before controls. Specified systems include airless spray, electrostatic spray, electrostatic bell or disc,

STAPPA/ALAPCO *Recommendation*

► Until the regulatory negotiation is completed, state and local agencies should consider implementation of Regulation 8, Rule 32 of the BAAQMD. This rule can achieve significant emission reductions and will encourage development of new technology.

heated airless spray, roller coat, brush or wipe or dip and drain.

California's Bay Area Air Quality Management District's (BAAQMD's) Regulation 8, Rule 32 subjects general wood products, such as cabinets, vanities, shutters, containers, frames, tools and ladders, to lower overall standards than furniture and custom millwork, which include, among others, shop-finished wood products (panels, doors and trim), tables, chairs, beds and dressers. In addition, high transfer efficiency application methods are required, as are procedures to minimize emissions from solvent preparation and cleanup.

California's South Coast Air Quality Management District (SCAQMD) Rule 1136, as amended August 2, 1991, specifies maximum VOC concentrations for coatings. Limits range from 2.3 to 6.3 pounds of VOC per gallon for various coatings, effective July 1, 1994. Further reductions in VOC concentrations are mandated by July 1, 1996. Some local air districts in California have transfer efficiency provisions that require methods such as high-volume/low-pressure sprays.

Pennsylvania (25 Section 129.52, amended May 1992) also specifies a maximum VOC content for various coatings, applicable to facilities that emit VOCs in quantities of 3 pounds per hour or greater. The standard specifies VOC contents ranging from 5.5 pounds per gallon for enamels and opaque ground coats, to 6.8 pounds per gallon for semitransparent spray stains and toners.

Other state and local agencies with applicable rules for wood furniture coating include the following:

Massachusetts
New Jersey
New York (Part 22B and 205.1)
San Diego County Air Pollution Control District

(Rule 67.11)
Vermont (Regs. 5-253.12 and 5-261)

In addition, portions of rules regulating architectural coatings may be applicable for this source category.

REFERENCES

1. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. *Control of Volatile Organic Compound Emissions from Wood Furniture Coating Operations*. Draft.
2. Lake Michigan Air Directors Consortium. April 16, 1993. *Control of Emissions from Wood Furniture Coating [VOC]*.
3. National Air Pollutant Control Technical Advisory Committee. September 1991. *Review Draft of an Early CTG for Wood Furniture*.

4. Joint Industry Steering Committee. *An Evaluation of VOC Emissions Control Technologies for the Wood Furniture and Cabinet Industries*. 1992. ENSR Consulting and Engineering and National Economic Research Associates, Inc.

Table 1
Distribution of Wood Finishing Facilities by EPA Region

U.S. EPA Region	No. of Facilities
I	533
II	1,195
III	828
IV	2,821
V	1,823
VI	714
VII	299
VIII	275
IX	2,107
X	479

Table 2
Nationwide Impacts of Nine RACT Control Options

Option	Description	Nationwide Emissions Reduction (Mg/yr)	Reduction from Baseline (%)	Total Cost in Millions (\$)	Cost Effectiveness (\$/Mg)	Plants Controlled (%)
I	Full waterborne	94,774	71.6	229	2,418	100
II	Hybrid waterborne	73,395	55.5	147	7,007	100
III	Non-water	69,879	52.8	217	3,103	100
IV	Non-water hybrid	80,857	61.1	260	3,222	100
V	Hybrid→Add-on Control	91,200	68.9	347	3,805	100
VI ^a	A. No Recirculation	64,173	48.5	418	6,514	9.7
	B. With Recirculation	64,173	48.5	288	4,493	9.7
	C. With Air Curtain	66,060	49.9	209	3,168	9.7
VII ^b	A. No Recirculation	64,173	48.5	401	6,256	9.7
	B. With Recirculation	64,173	48.5	288	4,493	9.7
	C. With Air Curtain	66,060	49.6	209	3,168	9.7
VIII ^c	A. No Recirculation	64,173	48.5	348	5,420	9.7
	B. With Recirculation	64,173	48.5	249	3,875	9.7
	C. With Air Curtain	65,640	49.6	183	2,795	9.7
IX ^d	A. No Recirculation	64,173	48.5	331	5,162	9.7
	B. With Recirculation	64,173	48.5	224	3,809	9.7
	C. With Air Curtain	65,640	49.6	181	2,764	9.3

^aThermal recuperative incineration for all plants with flows equal to or less than 50,000 standard cubic feet per meter (scfm) AND thermal regenerative incineration for all plants with flows greater than 50,000 scfm.

^bCatalytic incineration for all plants with flows equal to or less than 50,000 scfm AND thermal regenerative incineration for all plants with flows greater than 50,000 scfm.

^cThermal recuperative incineration for all plants with flows equal to or less than 50,000 scfm AND combined adsorption/incineration for all plants with flows greater than 50,000 scfm.

^dCatalytic incineration for all plants with flows equal to or less than 50,000 scfm AND combined adsorption/incineration for all plants with flows greater than 50,000 scfm.

Table 3

Summary Table – Wood Furniture Coating

Affected Facilities	Facilities that finish wood household furniture, cabinets, store fixtures and office furniture.		
Number of Affected Facilities	More than 11,000 facilities employing approximately 390,000 people.		
National Emissions Estimates	Nationwide: 135,000 tpy of VOCs. Nonattainment Areas: 90,000 tpy of VOCs.		
VOC Emissions Range Per Facility	Small 50 tpy	Medium 225 tpy	Large 500 tpy
100 TPY Source Size	It is estimated that 1,056 facilities (9.6 percent of all facilities) are major sources.		
Potential Emissions Reduction Per Facility	Small 18 tpy	Medium 81 tpy	Large 180 tpy
Cost Effectiveness	Total Cost: \$147 million to \$418 million Cost Effectiveness: \$2,007 to \$6,514 per Mg of VOC		
Federal Rulemaking and/or Guidance Documents	Draft CTG and NESHAP are currently being developed as part of a regulatory negotiation; final rules are not expected until 1994.		
State and Local Control Efforts	<p>Illinois regulates large wood furniture coaters (those that emit more than 100 tpy) in the Chicago nonattainment area.</p> <p>Indiana regulates coated wood furnishers in nonattainment counties that emit 15 pounds per day or more, before controls. Systems specified include airless spray, electrostatic spray, electrostatic bell or disc, heated airless spray, roller coat, brush or wipe, or dip and drain.</p> <p>BAAQMD subjects general wood products to lower overall standards than furniture and custom mill work. High transfer efficiency application methods are required, as are procedures to minimize emissions from solvent preparation and cleanup.</p> <p>SCAQMD specifies maximum VOC concentrations for coatings, ranging from 2.3 to 6.3 pounds of VOCs per gallon for various coatings, effective July 1, 1994. Further reductions in VOC concentration are mandated by July 1, 1996.</p> <p>Pennsylvania specifies a maximum VOC content for various coatings, applicable to facilities emitting VOCs in quantities of 3 pounds per hour or greater. Limits range from 5.5 to 6.8 pounds per gallon.</p> <p>Massachusetts, New Jersey, New York, Vermont and San Diego also have rules related to wood furniture coating operations.</p>		
STAPPA/ALAPCO Recommendation	Consider adopting BAAQMD's Regulation 8, Rule 32 until the regulatory negotiation is completed.		

SECTION IV

Appendices

APPENDIX A

Frequently Used Acronyms

ACT – Alternative Control Technology

AIM – Architectural and Industrial Maintenance

*ALAPCO – Association of Local Air Pollution Control
Officials*

BAAQMD – Bay Area Air Quality Management District

BACM – Best Available Control Measure

BARCT – Best Available Retrofit Control Technology

CAAA – Clean Air Act Amendments of 1990

CARB – California Air Resources Board

CFFV – Clean Fuel-Fleet Vehicle

CO – Carbon Monoxide

CTG – Control Techniques Guideline

ECO – Employee Commute Options

EPA – U.S. Environmental Protection Agency

EtO – Ethylene Oxide

GVWR – Gross Vehicle Weight Rating

HAP – Hazardous Air Pollutant

HON – Hazardous Organic NESHAP

HVLP – High-Volume Low-Pressure

I/M – Inspection and Maintenance

LAER – Lowest Achievable Emission Rate

LEL – Lower Explosive Limit

LEV – Low-Emission Vehicle

MACT – Maximum Achievable Control Technology

*NESHAP – National Emission Standard for Hazardous Air
Pollutants*

NMHC – Nonmethane Hydrocarbon

NMOG – Nonmethane Organic Gas

NO_x – Nitrogen Oxide

NSPS – New Source Performance Standard

NSR – New Source Review

OBD – Onboard Diagnostics

OMB – *Office of Management and Budget*

POTW – *Publicly-Owned Treatment Works*

RACT – *Reasonably Available Control Technology*

RFG – *Reformulated Gasoline*

ROG – *Reactive Organic Gas*

RVP – *Reid Vapor Pressure*

SCAQMD – *South Coast Air Quality Management District*

SCM – *Suggested Control Measure*

SIC – *Standard Industrial Classification*

SIP – *State Implementation Plan*

SOCMI – *Synthetic Organic Chemical Manufacturing
Industry*

STAPPA – *State and Territorial Air Pollution Program
Administrators*

TCM – *Transportation Control Measure*

TLEV – *Transitional Low-Emission Vehicle*

TSDF – *Treatment, Storage and Disposal Facility*

ULEV – *Ultra Low-Emission Vehicle*

VMT – *Vehicle Miles Traveled*

VOC – *Volatile Organic Compound*

ZEV – *Zero Emission Vehicle*

APPENDIX B

Frequently Used Abbreviations for Units of Measure

acfm – *actual cubic feet per minute*

bbl – *barrel*

g/l – *grams/liter*

g/BHP-hr – *grams per brake horsepower hour*

gpm – *grams per mile*

kPa – *kilopascal*

MMBtu – *million British thermal units*

mg/m₃ – *microgram per cubic meter*

Mg – *megagram*

mmHg – *millimeters of mercury*

ppm – *parts per million*

ppmv – *parts per million volume*

ppmw – *parts per million weight*

psi – *pounds per square inch*

psia – *pounds per square inch actual*

SCFM – *standard cubic feet per minute*

tpy – *tons per year*

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